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BRUCE HEAVY WATER PLANT POSTOPERATIONAL AQUATIC SURVEY 1981

Report No 82-512-K

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ABSTRACT

The environmental impact on attached algae, zoobenthos and adult and juvenile fish of a thermal-H_2S plume emanating from Bruce Heavy Water Plant was assessed during May, August/September and October 1981. Attached algae abundance and distribution were extremely variable across the locations sampled, with no clear trends evident. Algal standing crops were comparable to those obtained during the 1979 BNPD postoperational survey, and did not exceed a mean monthly biomass of 25 gm/m^2 for the seven shoreline sampling sites. Oligochaetes (especially Naididae) and dipterans dominated the zoobenthos collections. There was a tendency for zoobenthic organisms to be more numerous in shallow lake water areas especially in May and October. A typical alewife - longnose sucker - white sucker species complex dominated the BHWP nearshore area. Catch per unit effort (CUE) did not vary significantly between locations sampled. The maximum total sulphide concentration recorded during the study was 16 µg/L.

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*Appendices IV and VIII are contained on microfilm.

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To Mr. G.R. Childerhose
Manager
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Environmental Protection
Nuclear Generation Division

BRUCE HEAVY WATER PLANT
POSTOPERATIONAL AQUATIC SURVEY
1981

1.0 INTRODUCTION

This report constitutes an analysis of the environmental impact on attached algae, zoobenthos and adult and juvenile fish of a thermal-hydrogen sulphide (H_2S) plume emanating from the northern outfall of Bruce Heavy Water Plants A and B (BHWP-A and BHWP-B) during May, August/September, and October 1981. The study was requested by Radioactivity Management and Environmental Protection Department of Nuclear Generation Division, and was conceived as an interdisciplinary project whereby personnel of the RMEP Department were responsible for determination of the thermal-H_2S plume configurations during specified dates in May, August and October, coincident with the collection of aquatic biological material by Biological Research Section.

During this study emphasis was placed on the possible influence of the BHWP thermal-H_2S plume on the abundance and distribution of the attached algae, zoobenthos, and adult and juvenile fish in the nearshore region adjacent to BHWP. These three groups of organisms are commonly studied in aquatic monitoring programs, since they are sensitive to changes in water quality and represent different trophic levels in the aquatic ecosystem (Herricks and Cairns, 1982). No single taxon can adequately reflect changes in the condition of the aquatic environment, therefore an integrated approach involving several taxa is desirable (Karr, 1981). The simultaneous assessment of attached algae, benthic macroinvertebrates and fish was considered appropriate to identify potential environmental effects of the BHWP thermal-H_2S plume on the nearshore aquatic biological community.

2.0 METHODS

2.1 Sampling Locations and Schedule

The study area for the 1981 Bruce Heavy Water Plant (BHWP) thermal-hydrogen sulphide plume study encompasses a 2.0 km stretch of shoreline from just north of the Bruce GS 'B' to immediately south of Macpherson Bay. The area sampled extends approximately 0.8 km from shore, to the 15 m depth contour. A total of seven transects (A to G inclusive) separated from one another by a distance of approximately 375 m were sampled for benthic macroinvertebrates and attached algae. Four transects (A, C, E and G) located 750 m from one another were fished with gill and trap nets. Sulphide samples were taken only at those four transects where fish sampling was conducted. Attached algae and fish sampling was performed during May, August and October, whereas zoobenthos sampling was performed during May, September and October. These dates were selected to simulate spring (May), summer (August/September) and fall (October) conditions. Rough weather prevented the execution of zoobenthos sampling in August, as originally planned. However since zoobenthos sampling occurred early in September, it is unlikely that the results were appreciably biased.

2.2 Physical Characteristics

2.2.1 Temperature

Surface water temperatures were recorded with a temperature-oxygen meter (Hydrolab Model 2000) in conjunction with (a) the collection of attached algae along transects A to G and (b) the collection of fish at the 3 m and 12 m depth contours along transects A, C, E and G. Bottom water temperatures were recorded at each zoobenthos sampling location (see Figure 2.1-1).

2.2.2 Thermal-H_2S Plume

Thermal-hydrogen sulphide plume configurations at BHWP were determined by personnel of the Radioactivity Management and Environmental Protection (RMEP) Department coincident with aquatic biological sampling during May, August and October. Previous studies (Ontario Hydro Reports RMEP-IR-090-9 and CNS-IR-090-2) have indicated that models of dilution developed for temperature are good approximations of hydrogen sulphide dilution, as hydrogen sulphide disperses with the warm surface water plume. RMEP personnel are currently utilizing a modified version of the phenomenological model developed by Elliott and Harkness (1972) to describe thermal plumes.

2.3 Chemical Characteristics

2.3.1 Water Chemistry

The results of an earlier report (Ontario Hydro Report RMEP-IR-090-9) indicated that total sulphide concentrations

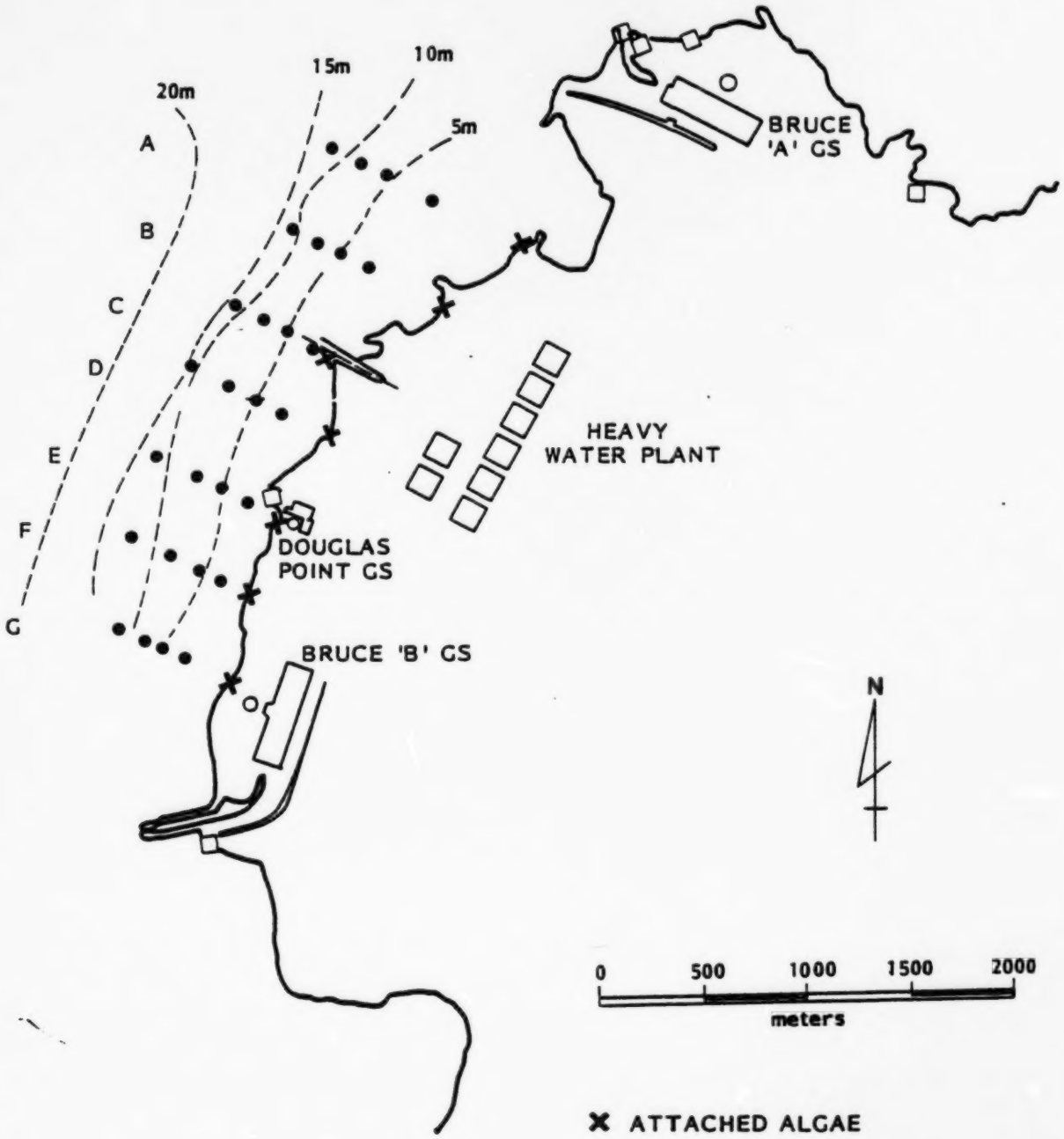

FIGURE 2.1-1

ATTACHED ALGAE AND MACROINVERTEBRATE
SAMPLING LOCATIONS
BHWP - 1981

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dropped to 0.0 µg/L at a depth of only 4 m, suggesting that hydrogen sulphide does not impinge upon the substrate and thus upon the zoobenthos at a depth of 4 m or greater during summer months. However the possibility that such impingement could occur was investigated at the new northern outfall of BHWP by determining the bottom water total suphide content at the 3, 5, 7 and 12 m depth contour marks along transect C (BHWP discharge). In addition, surface water total sulphide levels were measured during fish sampling (3 m and 12 m depth contours) and attached algae sampling (1 m depth contour) along transects A, C, E and G. Total sulphide levels were monitored (a) when gill nets were initially set (b) when gill nets were pulled and reset and (c) when gill nets were lifted again. Water analyses were performed by Analytical Services Section of Research Division, using an automated procedure developed specifically for determination of sulphide in water (Ontario Hydro Research Division Report 79-181-K). The technique is a colorimetric one in which a chromophore (methylene blue) is formed by the reaction of sulphide, ferric chloride, and p-aminodimethylaniline. The minimum detection limit for the procedure is approximately 2.0 µg/L of total sulphide.

2.4 Biological Characteristics

2.4.1 Attached Algae

Attached algae (filamentous and associated algae) are sessile, sensitive to environmental temperatures, and often reflect water quality conditions of the immediate past (Weitzel, 1979), and were sampled as follows. Triplicate attached algae samples were collected from shoreline natural substrates on transects A, B, D, F and G and from the wall of the discharge channels on transects C and E during each sampling period in May, August and October (Figure 2.1-1). Attached algae samples were scraped from a 25 cm^2 area of substrate, preserved, speciated, dried to constant weight for 24 h and ashed at 525°C. Results were expressed as g/m^2 of ash-free dry weight. It should be mentioned that biomass estimates include an undetermined portion of detrital matter. Analysis of variance was performed to expose temporal and spatial differences in attached algae biomass.

2.4.2 Zoobenthos

Benthic invertebrates are considered as good indicators of water quality because they are sedentary organisms, have a widespread distribution, are a major source of fish food, and can be very abundant under favourable environmental conditions (Britt, 1974; Smith, 1974). Triplicate zoobenthos samples were collected with a 105 cm^2 vacuum dome at depths of 1, 3, 5, 7 and 12 m on the seven transects shown in Figure 2.1-1 during May, September and October. Densities of zoobenthic organisms were recorded as numbers/m^2. Analysis of variance of density estimates was performed to identify spatial and temporal differences in the data. Diversity indices (number of taxa = species richness; Shannon-Weiner Index = species evenness) were calculated to accentuate

differences in species composition among sampling locations. Zoobenthic data was also subjected to Mutual Information Analysis (Orloci, 1969).

2.4.3 Adult and Juvenile Fish

Fish have been used extensively in biomonitoring programs since they are relatively easy to identify, and substantial life history information exists for many fish species (Karr, 1981). Adult and juvenile fish were collected on the three sampling dates by trap nets and gill nets along transects A (Macpherson Bay), C (BHWP discharge), E (Douglas Point discharge) and G (Lagoon Bay). Experimental gill nets consisted of nine 15 m panels with mesh sizes ranging from 2.6 cm to 12.7 cm (1.25 cm increments). Sets of gill nets were placed at the surface and on the bottom at each of the 3 to 5 m and 12 to 15 m depth contours, in a direction perpendicular to the shoreline (Figure 2.4.3-1). Two consecutive 24-h gill net sets were made during each sampling period. Pairs of 1.2 m trap nets were set on the four transects as indicated in Figure 2.4.3-1 for two consecutive 24-h sets on each of the three sampling dates. Both gill and trap net fish catches were speciated and counted. Spatial and temporal differences in fish distribution and abundance were compared by analysis of variance of catch per unit effort (CUE) data. Catch per unit effort is defined as the catch per 24-h period per gill or trap net.

3.0 RESULTS AND DISCUSSION

3.1 Physical Characteristics

3.1.1 Temperature

Surface water temperatures recorded during fish sampling in the vicinity of BHWP are presented in Table 3.1.1-1 and shoreline surface water temperatures recorded during attached algae sampling are shown in Table 3.1.1-2. These tables show elevated temperatures at BHWP discharge (transect C), transect E (Douglas Point discharge), and transect F, with surface water temperatures measured at the 3 m depth contour averaging 6 to 8°C higher than surrounding areas in May and October, and 2 to 3°C higher in August. Surface water temperatures at the 12 m depth contour were similar for all transects (A, C, E and G) sampled during fish collections (Table 3.1.1-1). This thermal regime is typical for surface thermal discharges in the Bruce Nuclear Power Development (BNPD) area.

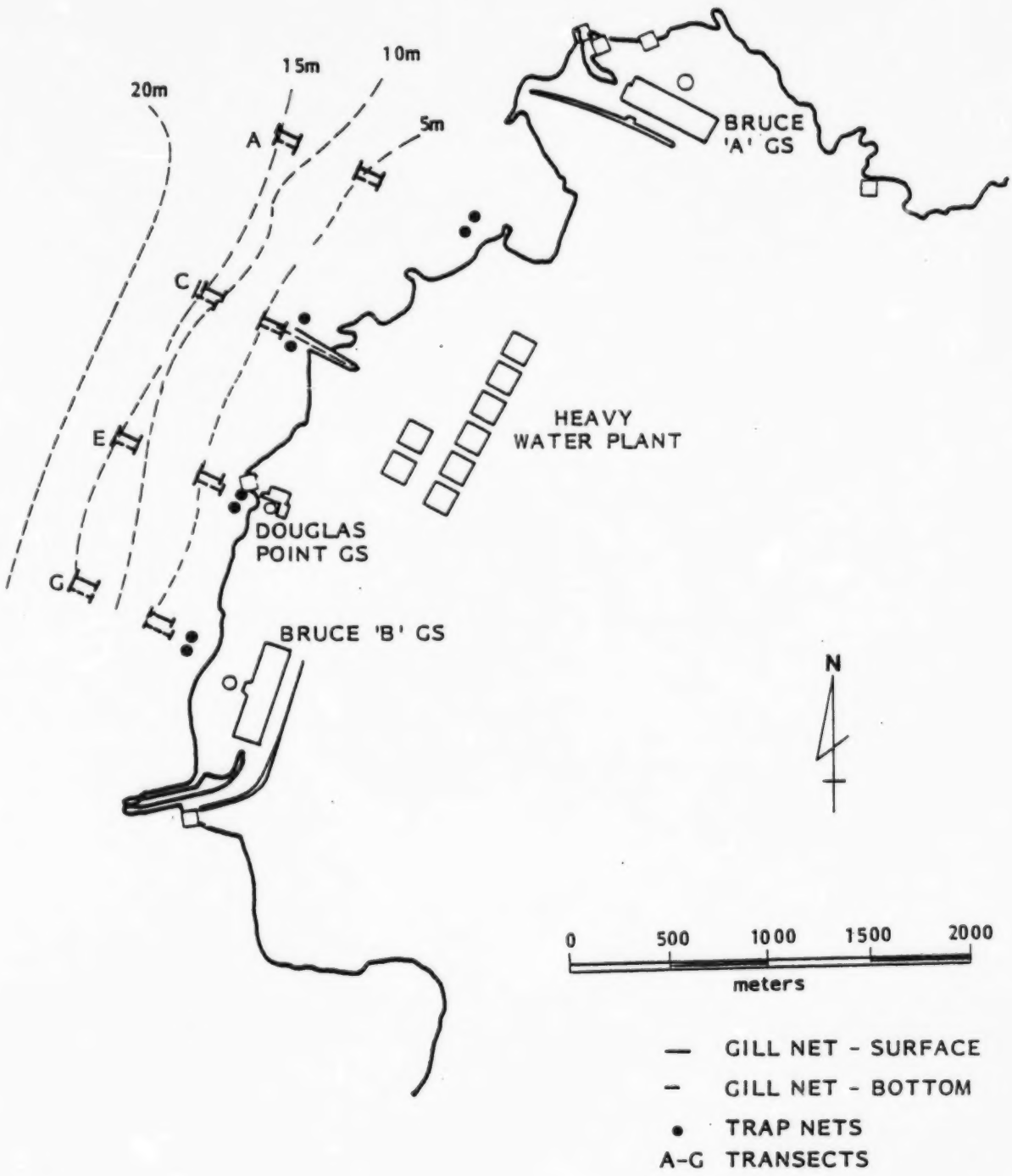

FIGURE 2.4.3-1

GILL NET AND TRAP NET LOCATIONS
BHWP - 1981

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TABLE 3.1.1-1

MEAN SURFACE WATER TEMPERATURES (°C) RECORDED DURING FISH SAMPLING AT TRANSECTS A, C, E AND G IN MAY, AUGUST, OCTOBER - BHWP - 1981

Transect	Contour Depth (m)	Gill Net			Trap Net		
		May	Aug	Oct	May	Aug	Oct
A	3	10.9	19.6	10.5	11.7	18.7	11.8
	12	11.4	19.3	10.2			
C	3	15.9	20.3	17.9	14.5	19.5	14.6
	12	10.5	19.7	11.0			
E	3	11.9	22.0	12.7	15.0	23.6	11.0
	12	10.3	19.5	10.9			
G	3	11.5	19.8	10.6	12.4	19.5	10.3
	12	10.4	19.6	10.6			

Bottom water temperatures are presented in Table 3.1.1-3. The bottom temperature profile along transects A to G at 1 m and 3 m depth contours resembled that of the surface waters. Elevated temperatures indicative of a thermal plume were observed at the 3 m depth contour of BHWP discharge in May, the 1 m depth contour of Douglas Point discharge during August and October, and the 1 m and 3 m depth contours of BHWP discharge in October. Beyond the 3 m depth contour, bottom temperatures were generally lower than those at shallower locations. In May the mean bottom temperature (across transects) declined from 11.8°C at the 1 m depth contour to 5.4°C at the 12 m depth contour. August bottom water temperatures, although higher than May temperatures, showed a similar pattern of sharply declining temperatures beyond the 3 m depth contour. In contrast, October bottom water temperatures at the 3 m and 12 m depth contours were within 1°C of each other, with the single exception of transect C (BHWP discharge) where a 5°C difference in temperature was noted. The maximum bottom temperature occurred at the 1 m depth contour of Douglas Point discharge during August (24.7°C).

TABLE 3.1.1-2

SHORELINE SURFACE WATER TEMPERATURES (°C) AT TRANSECTS A TO G DURING MAY, AUGUST AND OCTOBER - BHWP - 1981

Transect	May 28	August 25	October 29
A	11.0	20.0	8.2
B	13.5	20.0	9.3
C	13.5	22.0	14.4
D	8.0	20.1	9.7
E	16.0	24.0	19.2
F	14.0	22.5	13.8
G	11.0	20.0	9.9

TABLE 3.1.1-3

BOTTOM WATER TEMPERATURES (°C) AT 1, 3, 5, 7 and 12 m DEPTH CONTOURS ALONG TRANSECTS A TO G DURING MAY, AUGUST AND OCTOBER BHWP - 1981

Month	Contour Depth (m)	A	B	C	D	E	F	G	Means
May	1	15.0	12.0	11.0	11.5	11.0	11.0	11.0	11.8
	3	9.0	9.0	12.5	6.5	7.0	6.5	6.0	8.1
	5	8.5	7.5	7.0	6.0	6.5	6.5	6.5	6.9
	7	6.0	7.0	6.0	6.0	6.0	6.5	6.0	6.2
	12	5.0	5.0	5.5	5.0	6.0	6.0	5.5	5.4
August	1	19.1	19.6	19.5	18.8	24.7	19.8	20.0	20.2
	3	19.4	19.3	19.5	19.8	19.6	19.8	19.8	19.6
	5	18.5	17.6	18.6	18.6	19.1	18.7	18.3	18.5
	7	16.5	16.7	17.0	17.8	17.8	19.0	19.0	17.7
	12	14.2	14.2	13.6	14.8	14.0	14.8	16.0	14.5
October	1	10.5	10.1	17.0	10.0	19.2	9.4	9.9	12.3
	3	10.5	10.1	15.0	10.0	9.2	9.4	9.1	10.5
	5	10.5	10.1	9.9	10.0	9.0	9.3	9.2	9.7
	7	10.1	10.1	9.9	9.9	9.0	9.6	9.2	9.7
	12	9.9	10.0	9.9	9.9	9.0	9.6	9.2	9.6

3.1.2 Thermal - H_2S Plume

Plume configurations for each of the sampling periods during May, August and October are presented in Figures 3.1.2-1, 3.1.2-2 and 3.1.2-3. Table 3.1.2-1 contains empirical values of several parameters used to model the plume configurations on the respective sampling dates. Current speed and direction influenced the shape and direction of each plume. During May 25-26 a relatively

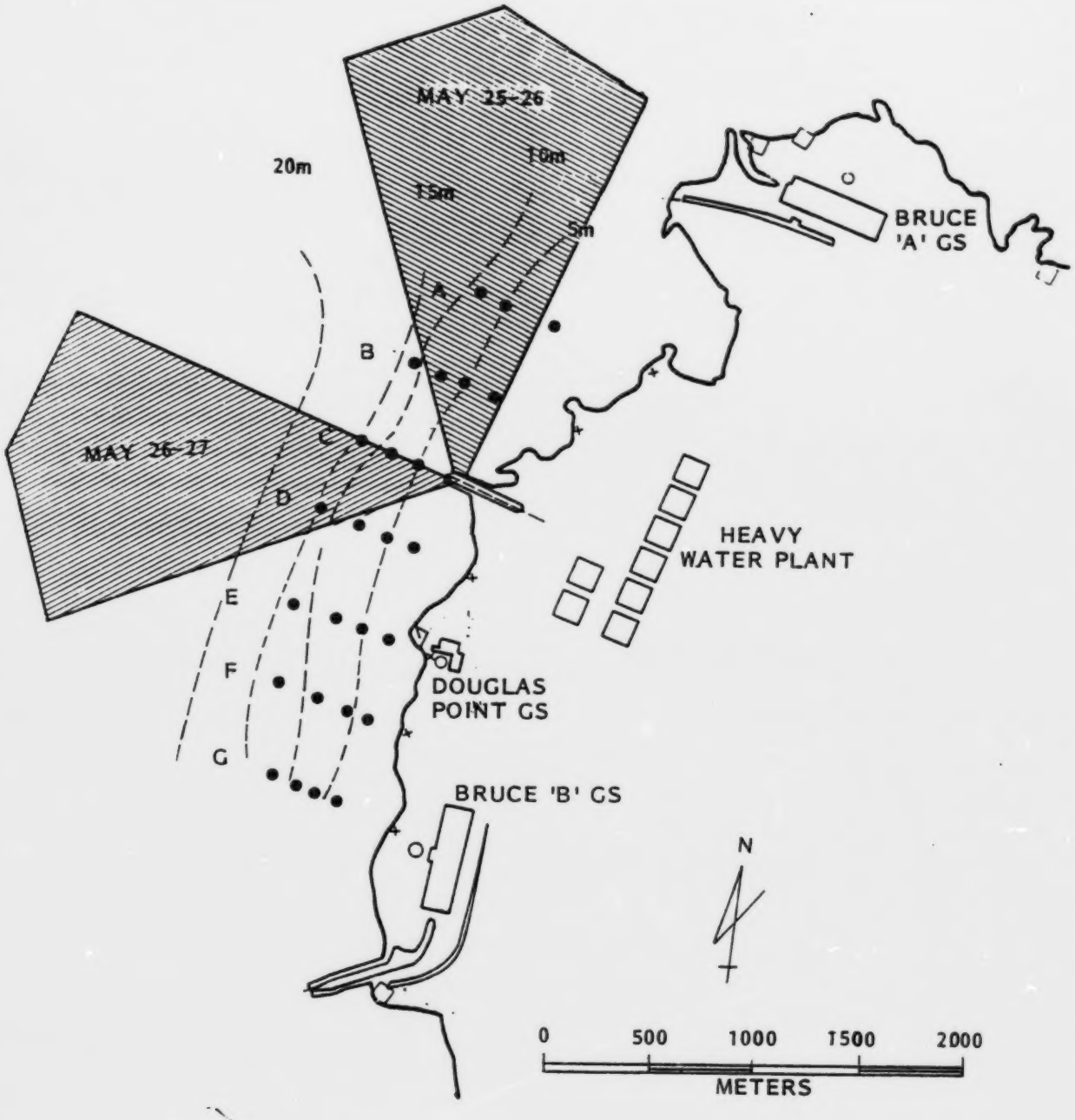

FIGURE 3.1.2-1

MAY PLUME CONFIGURATIONS
BHWP - 1981

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weak (10 cm/s) current shifted the plume to a position north of the BHWP discharge area. The May 26-27 plume was calculated to occupy a location just south of the outfall area. By comparison the August 25-26 and August 26-27 plumes were estimated to occupy extreme southward and centralized positions (relative to BHWP discharge) respectively. Plume configurations for the periods October 25-26 and October 27-28 were similar to those derived during August. Based on the current speed and direction during May 26-27, August 25-27 and October 25-28, it is likely that some impingement of the Bruce NGS 'A' thermal plume would have taken place. This impingement would have only affected the surface water (1 m vertical depth) temperature.

The mean $\Delta T(°C)$ for Douglas Point discharge during the May, August and October sampling periods was 8.8°C, 5.4°C and 9.4°C respectively, while the mean $\Delta T(°C)$ for BHWP discharge was 8.0°C during each of the sampling intervals. These data are consistent with measured surface water temperatures which indicated a maximum (1 m to 12 m depth contour) ΔT of 8.3°C for Douglas Point discharge and 7.4°C for BHWP discharge (Tables 3.1.1-1 and 3.1.1-2). Thus the thermal plumes associated with BHWP and Douglas Point GS were similar with respect to their established thermal gradients.

Measurable total sulphide levels (maximum 16 µg/L) were generally within the areas calculated for plume configurations during the three sampling periods. However there were several occasions when total sulphide concentrations greater than the limit of detection (2 µg/L) were recorded outside of the calculated plume area (Table 3.1.2-2). Along the BHWP discharge transect (C) total sulphide concentrations of 9 to 14 µg/L were measured at 5 m and 7 m depth contours when it was predicted that the plume centreline had been redirected northward (May 25-26) or southward (October 27-28) by alongshore currents. A total sulphide level slightly exceeding the detectable limit (5 µg/L) was recorded at the 3 m depth contour on May 25 outside of the predicted plume area. These results indicate that the current plume model, although constituting a reasonable approximation of hydrogen sulphide dispersion in surface waters, did not account for some instances when total sulphide concentrations ranged between 3 and 14 µg/L. Previous hydrographic work in the BNPD nearshore area has demonstrated that both steady and unsteady periods of current activity occur. During unsteady periods (eg, see Figure 3.1.2-1), current speed and direction can change within several hours (Ontario Hydro Hydraulic Studies Department Report No 77222). Thus variation in current speed and direction in the BHWP nearshore zone experienced during this survey probably contributed to the occurrence of measurable amounts of hydrogen sulphide beyond the perimeter of predicted plumes.

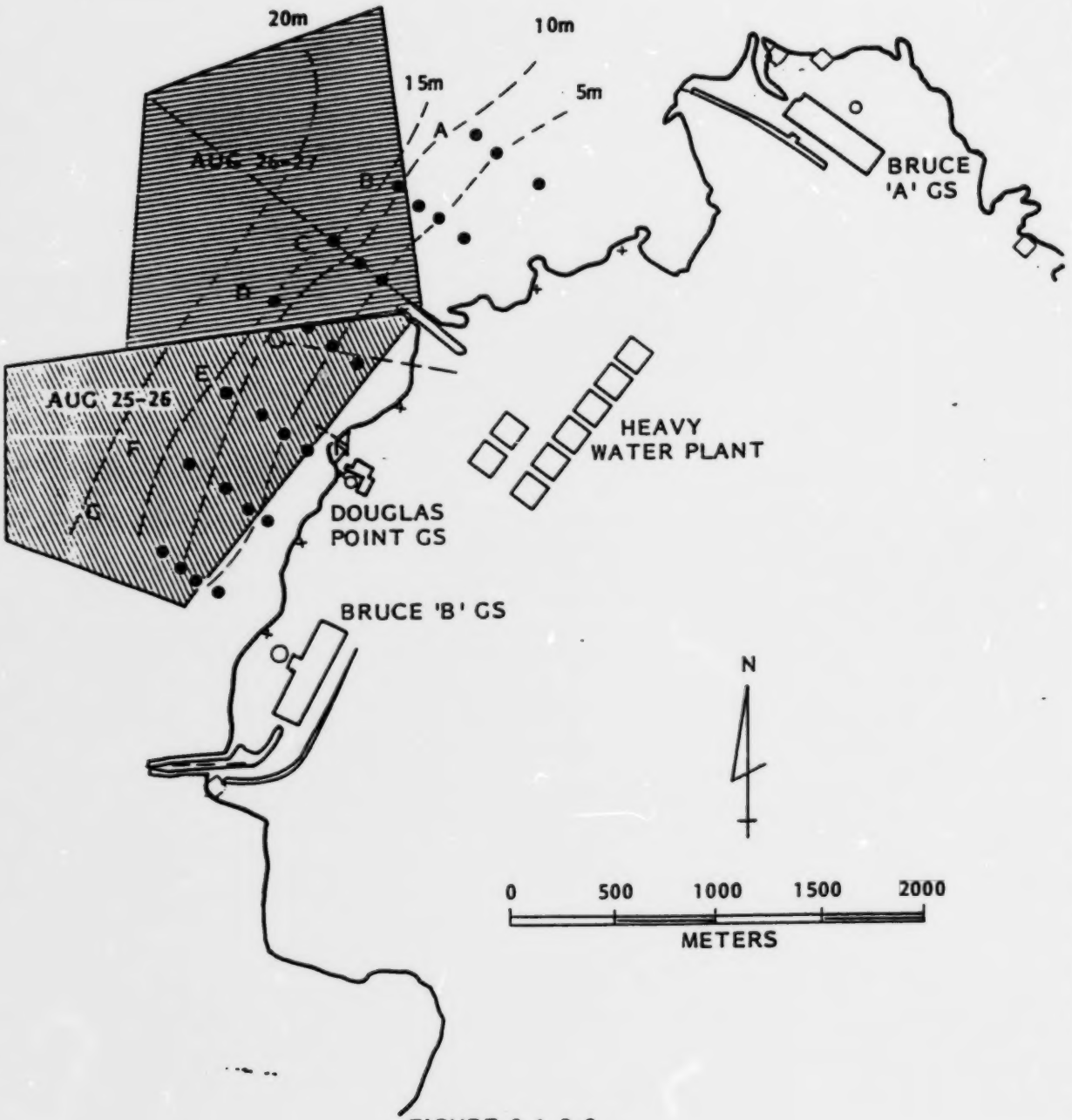

FIGURE 3.1.2-2

AUGUST PLUME CONFIGURATIONS
BHWP - 1981

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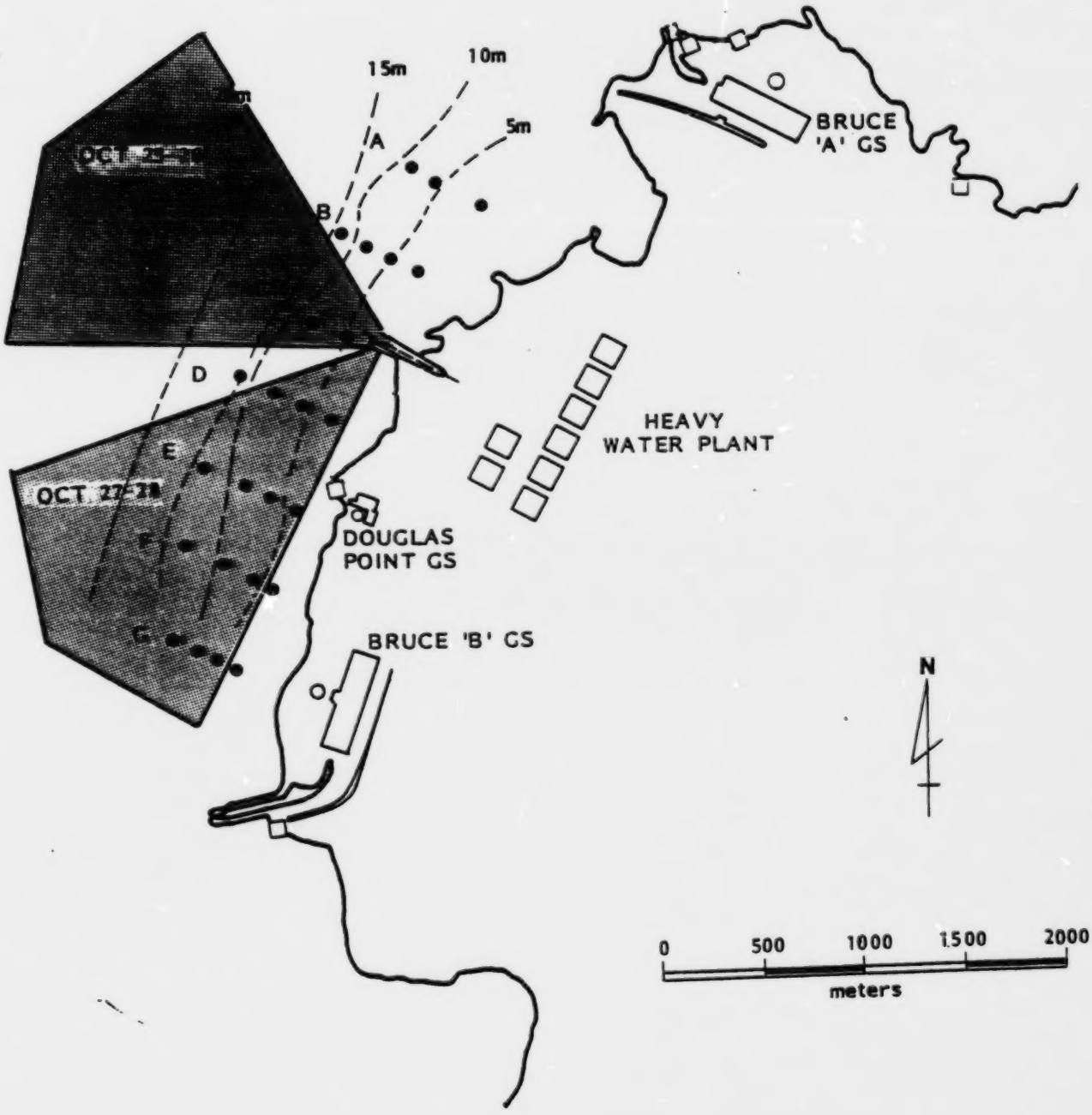

FIGURE 3.1.2-3
OCTOBER PLUME CONFIGURATIONS
BHWP - 1981

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TABLE 3.1.2-1

SURVEY PARAMETERS USED TO CALCULATE PLUME CONFIGURATIONS, BHWP - 1981

Date	Current		Temperature		BHWP Discharge
	Speed (cm/s)	Direction (deg)	BHWP (°C) Discharge	(°C) Ambient Water	Flow Rate (Mg/s)
First Survey					
May 25 - 26	10	45	16	8	35.5
May 26 - 27	3	225	16	8	35.5
Second Survey					
Aug 25 - 26	11	225	25	17	19.7
Aug 26 - 27	15	120	25	17	19.7
Third Survey					
Oct 25 - 26	4	130	19	11	19.8
Oct 27 - 28	14	225	19	11	19.8

TABLE 3.1.2-2

RECORDED TOTAL SULPHIDE LEVELS OUTSIDE OF THE INFLUENCE OF CALCULATED PLUMES, BHWP-1981

Date	Transect	Depth Contour	Total Sulphide (µg/L)
May 25	C	5 m (bottom)	10
May 25	E	3 m (surface)	5
October 27	C	5 m (surface)	9
October 27	C	7 m (surface)	10
October 28	C	5 m (surface)	14

3.2 Chemical Characteristics

3.2.1 Water Chemistry

Total sulphide levels ranged from <2 µg/L to 16 µg/L during the entire sampling period at BHWP in 1981 (Table 3.2.1-1). The maximum concentration (16 µg/L) occurred in surface water samples in the 1 m depth zone of BHWP discharge on October 28, and in bottom water samples at the 3 m depth contour along the BHWP discharge transect (C) on October 27. Sulphide levels recorded

TABLE 3.2.1-1

SUMMARY OF TOTAL SULPHIDE CONCENTRATIONS ($\mu g/L^{-1}$)
DETERMINED ALONG TRANSECTS A, C, E AND G
DURING MAY, AUGUST AND OCTOBER BHWP - 1981

Transect	Contour Depth (m)	May			August			October		
		25	26	27	24	25	26	26	27	28
A	1*	<2	<2	<2	<2	<2	<2	<2	<2	<2
	3*	<2	<2	<2	<2	<2	<2	<2	<2	<2
	12*	<2	<2	<2	<2	<2	<2	<2	<2	<2
C	1*	5	<2	6	<2	<2	<2	5	5	16
	3*	8	10	11	<2	<2	<2	13	15	12
	3**	<2	10	<2	<2	3	<2	2	16	4
	5*	-	-	-	-	-	-	13	9	14
	5**	10	<2	<2	<2	<2	<2	<2	<2	<2
	7*	-	-	-	-	-	-	16	10	<2
	7**	2	<2	<2	<2	<2	<2	<2	<2	<2
	12*	<2	<2	<2	<2	<2	<2	5	2	<2
	12**	<2	<2	<2	<2	<2	<2	<2	<2	<2
E	1*	<2	<2	<2	<2	<2	<2	<2	2	<2
	3*	5	<2	<2	<2	<2	<2	<2	2	2
	12*	<2	<2	<2	<2	<2	<2	<2	2	3
G	1*	<2	<2	<2	<2	2	<2	<2	2	<2
	3*	<2	<2	<2	<2	<2	<2	<2	2	<2
	12*	<2	<2	<2	<2	<2	<2	<2	<2	<2

* Surface sample
** Bottom sample

along transects A, E and G were primarily below the detection limit of 2 µg/L (Table 3.2.1-1). In the BHWP discharge area, where the highest sulphide levels should be expected, total sulphide concentrations peaked in the 1 m to 5 m depth zone during May and October, with values ranging from 8 to 16 µg/L.

At the 12 m depth contour along transect C, hydrogen sulphide was undetectable in surface and bottom water samples during May and August, however October samples still contained small quantities of sulphide (2 to 5 µg/L). Notably, August total sulphide concentrations were consistently low (maximum 3 µg/L at the 3 m depth contour on August 25), irrespective of the transect sampled. Although an earlier report indicated that hydrogen sulphide was not measurable below the 4 m depth (Ontario Hydro Report RMEP-IR-090-9), the results of this study show that sulphide was present at a bottom concentration of 10 µg/L at the 5 m depth contour. Bottom water total sulphide levels rarely exceeded surface water sulphide concentrations, and were not detectable beyond the 5 m depth contour.

3.3 Biological Characteristics

3.3.1 Attached Algae

Species Composition

Fifteen taxa of attached algae and three taxa of epiphytic algae were collected at the shoreline locations on transects A to G during May, August and October (Table 3.3.1-1). Averaged over all sampling locations, Ulothrix zonata was the most abundant species in May (34%) and October (38%) samples. U. zonata was also the most prominent species collected (23%) for samples averaged over all sampling locations and periods (Table 3.3.1-1). Of the remaining 14 taxa, only Mougeotia sp (18%) and Rhizoclonium sp (12%) comprised more than 10% of the samples averaged over all locations and months. Less dominant algal taxa included Ulothrix sp (8%), Cladophora glomerata (8%) Stigeoclonium sp (8%), Bulbochaete sp (7%) and Zygnema sp (6%). The three epiphytic algae found were Cocconeis sp, Cymbella sp and Rhoicosphenia sp.

Several researchers have identified a shift in algal species dominance on the Lake Erie shoreline. Ulothrix zonata invades the shoreline area in spring at temperatures below 5°C. As the water temperature increases Cladophora spp (mainly C. glomerata) gradually replace Ulothrix until Cladophora dominates the shoreline at temperatures between 15 to 18°C (Taft, 1975; Kirby and Dunford, 1981). This pattern of algal succession was not observed during the 1979 Bruce Nuclear Power Development (BNPD) aquatic survey, when Ulothrix persisted throughout the summer months. It was suggested that several large temperature reductions associated with upwellings contributed to the persistence of Ulothrix in that year (Ontario Hydro Research Division Report 82-107-K).

In the present study there was a high degree of algal variability among locations, with little evidence of a Ulothrix to Cladophora dominance shift (Table 3.3.1-2). During the May sampling period Ulothrix dominated the shoreline at Macpherson Bay, Lagoon Bay and in the BHWP discharge channel. However Mougeotia dominated at transects B and F, while Cladophora was the main alga present at the Douglas Point discharge (Table 3.3.1-2). The dominance of Cladophora at the Douglas Point discharge channel during May was probably a consequence of elevated water temperatures, since the surface water temperature at the Douglas Point discharge was 16.0°C on May 28. At the shoreline sites dominated by Ulothrix in May (Macpherson Bay, BHWP discharge and Lagoon Bay), water temperatures were between 2.5 and 5.0°C lower than those observed at Douglas Point discharge (Table 3.1.1-2).

Ulothrix was noticeably absent from August samples at all locations, and was replaced by a Coleochaete/Mougeotia/Rhizoclonium complex at Macpherson Bay, by Rhizoclonium alone at BHWP discharge, and by Cladophora glomerata at Lagoon Bay. Mougeotia was replaced by Bulbochaete at transect B and by a combination of Bulbochaete and Zygnema at transect F.

Algal dominance during the October sampling period was also variable, with the Coleochaete/Mougeotia/Rhizoclonium group retaining dominance at Macpherson Bay, while Rhizoclonium remained the dominant algal taxon at the BHWP discharge. For the remaining shoreline locations, October samples revealed either a total dominance by Ulothrix zonata (transects B and D and Lagoon Bay), or shared dominance between Ulothrix zonata and Cladophora glomerata (Douglas Point discharge and transect F). Lagoon Bay was therefore the only sampling location where Cladophora superceded Ulothrix. Notably Ulothrix zonata resumed its dominance in Lagoon Bay during October, when the water temperature had decreased to 10°C (Table 3.1.1-2). However Ulothrix zonata did not regain dominance in the BHWP discharge channel during the October sampling period, when the water temperature was greater than 14°C (Table 3.1.1-2). Instead Rhizoclonium became the dominant attached algae in the BHWP discharge during August and October, when Cladophora would normally dominate (Table 3.3.1-3). Rhizoclonium and Cladophora are morphologically similar algae (Prescott, 1962), however the former taxon is relatively rare in comparison with the latter taxon. Rhizoclonium was not present on natural substrates in any of the three preoperational BNPD aquatic surveys (Ontario Hydro Research Division Reports 74-449-H, 75-323-H and 76-343-K), but occurred at Douglas Point discharge in October, 1978 (Ontario Hydro Research Division Report 80-43-K), Bruce GS 'A' discharge in 1979 (Ontario Hydro Research Division Report 82-107-K) and at BHWP discharge in August, October and November, 1981 (Ontario Hydro Research Division BNPD postoperational Year III Report - in preparation). The specific environmental conditions which favour the growth of Rhizoclonium over Cladophora are presently unknown.

TABLE 3.3.1-1

PER CENT COMPOSITION OF ATTACHED ALGAL SAMPLES - BHWP, 1981

	May	Aug	Oct	Season
Ulothrix zonata	34	1	38	23
Mougeotia sp	29	17	6	18
Rhizoclonium sp	--	19	16	12
Ulothrix sp	16	<1	8	8
Cladophora glomerata	10	6	8	8
Stigeoclonium sp	3	12	6	8
Bulbochaete sp	--	17	--	7
Zygnema sp	8	8	--	6
Calothrix sp	--	12	3	6
Coleochaete sp	--	4	6	3
Anabaena sp	--	--	6	2
Oedogonium sp	--	1	3	1
Oscillatoria sp	--	2	<1	1
Cladophora sp	--	<1	--	<1
Spyrogyra sp	<1	<1	--	<1
Total no of taxa	7	14	11	15

TABLE 3.3.1-2

DOMINANT ATTACHED ALGAE AT SHORELINE LOCATIONS
BHWP, 1981

Location	May 28	August 25-26	October 29
Macpherson Bay (A)	Us	C/M/R	C/M/R
Transect B	M	B	Uz
BHWP discharge (C)	Uz	R	R
Transect D	*	M	Uz
Douglas Point Discharge (E)	Cg	S	Cg/Uz
Transect F	M	B/Z	Cg/Uz
Lagoon Bay (G)	Uz	Cg	Uz

Legend

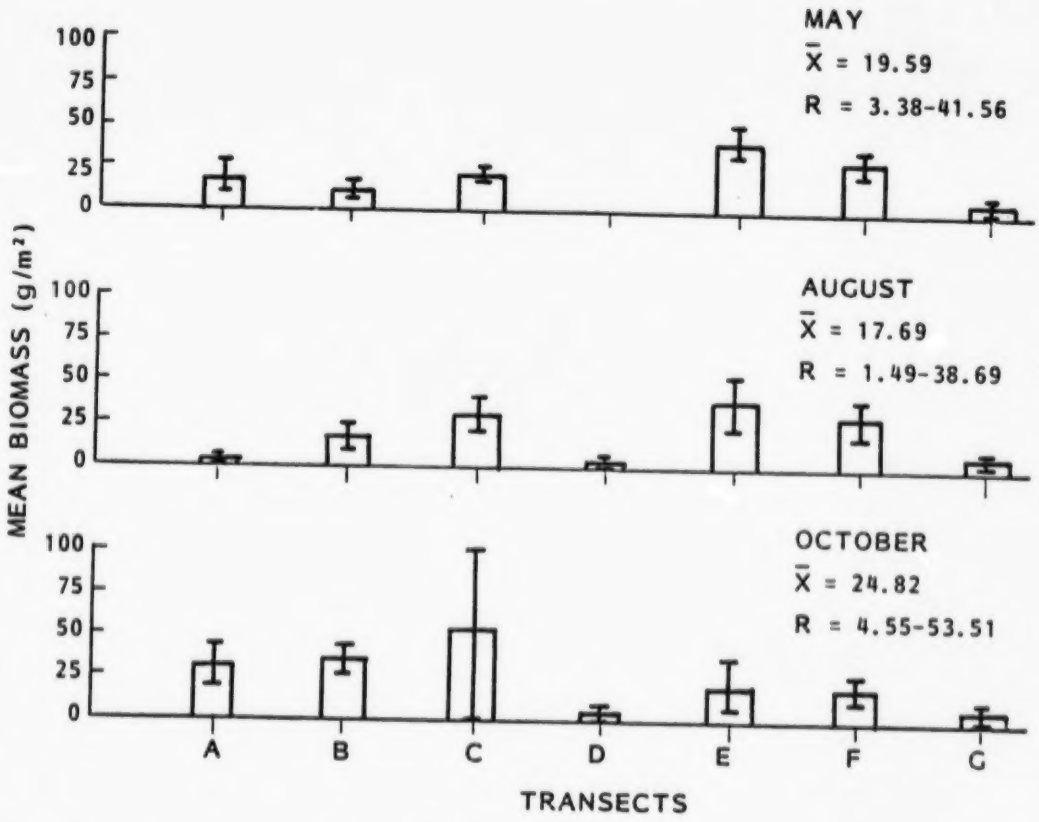
B - Bulbochaete sp
C - Coleochaete sp
Cg - Cladophora glomerata sp
M - Mougeotia sp
R - Rhizoclonium sp
S - Stigeoclonium sp
Us - Ulothrix sp
Uz - Ulothrix zonata
Z - Zygnema

* - No algal growth

Biomass Estimates

Standing crops of attached algae collected in shoreline samples are depicted in Figure 3.3.1-1. In May, mean biomass of attached algae ranged from 0.0 g/m^2 at transect D to 41.56 g/m^2 at Douglas Point discharge. Analysis of variance indicated that the biomass of attached algae differed significantly among shoreline locations (Appendix I). The Student-Newman-Keuls multiple comparison test demonstrated that the Douglas Point discharge algal biomass (41.56 g/m^2) was significantly higher than algal biomass at all other shoreline sites, and that algal standing crops at transect D and Lagoon Bay (3.33 g/m^2) sites were significantly lower than standing crops at all other locations except transect B (Figure 3.3.1-1; Appendix II). The high degree of variability among biomass samples resulted in several overlapping nonsignificant groups of biomass values, eg, the algal standing crop at Macpherson Bay (17.07 g/m^2) was not significantly different from that which occurred at either transect B (8.04 g/m^2) or BHWP discharge (20.04 g/m^2) and transect F (27.68 g/m^2), although the standing crops at the latter two locations were significantly higher than that at transect B (Appendix II).

August algal samples yielded mean biomass values ranging from 1.49 g/m^2 at Macpherson Bay to 38.69 g/m^2 at Douglas Point discharge. Analysis of variance showed that significant differences



A - MACPHERSON BAY
B - TRANSECT B
C - BHWP DISCHARGE
D - TRANSECT D
E - DOUGLAS POINT DISCHARGE
F - TRANSECT F
G - LAGOON BAY

FIGURE 3.3.1-1

BIOMASS OF ATTACHED ALGAE AT BHWP SHORELINE SAMPLING SITES, 1981
VALUES AT ALL LOCATIONS ARE MEANS (±STANDARD DEVIATIONS)
OF 3 REPLICATES FOR ASH-FREE DRY WEIGHT (g /m²)

82-512
156604-RD

existed among the seven estimates of algal standing crop, however the Student-Newman-Keuls multiple comparison test identified different relationships among the August samples than occurred in May. Mean biomass values of attached algae at BHWP discharge (27.53 g/m^2), Douglas Point discharge (38.69 g/m^2) and transect F (29.65 g/m^2) were significantly greater than standing crops at Macpherson Bay (1.49 g/m^2), Lagoon Bay (7.49 g/m^2) and transect D (2.29 g/m^2). Algal biomass at transect B (16.68 g/m^2) was not significantly different from that at Macpherson Bay, Lagoon Bay and transect D, or that at BHWP discharge and transect F, although standing crops at the two latter sites were significantly greater than at either Macpherson Bay, Lagoon Bay or transect D (Appendix II).

Mean biomass of attached algal samples collected in October were not significantly different from one another, although values ranged from 4.55 g/m^2 at transect D to 53.51 g/m^2 at BHWP discharge (Figure 3.3.1-1; Appendix I). Two-way analysis of variance of overall mean biomass values (location X month) revealed that overall mean biomass values did not differ significantly on a monthly basis. Conversely differences among overall locational mean biomass values were statistically significant (Appendix III). However there was no clear spatial distinction between average biomass values, ie, no single location had an algal standing crop which was significantly different from that at all other sites. Mean biomass values fell instead into a series of nested groups, each of which overlapped at least one other group. For example, standing crops (averaged over the three sampling periods) at Douglas Point discharge (34.32 g/m^2), BHWP discharge (33.69 g/m^2), transect F (26.23 g/m^2) and transect B (19.96 g/m^2) were not significantly different while standing crops at Lagoon Bay (6.00 g/m^2), Macpherson Bay (15.95 g/m^2) and transect B were not significantly different from one another (Appendix III). Collectively, standing crops at transect D (2.28 g/m^2), Macpherson Bay and Lagoon Bay were significantly smaller than standing crops at transects B and F, BHWP discharge and Douglas Point discharge (Appendix III). Algal standing crops in thermal discharge areas were generally greater than in adjacent areas, but not significantly so (Appendix III).

3.3.2 Zoobenthos

Taxonomic Composition and Density

The zoobenthic community in the nearshore zone adjacent to BHWP consisted of 75 taxa (species, species groups and families) which were associated with eight invertebrate orders and one class (Appendix X). Oligochaetes clearly dominated the benthic fauna, accounting for nearly 60% of all organisms collected. Approximately 25% of the total collection consisted of dipterans. Several invertebrate orders occurred in low abundance, including Ephemeroptera (May flies), Coleoptera (beetles), Trichoptera (caddis flies), Acarina (ticks and mites) and Amphipoda (Appendix X). Of the oligochaetes collected Nais pardalis and Nais variabilis predominated, representing 28% and 19% of the total

zoobenthos, respectively. Apart from the Tubificidae (2%), Nais simplex, (8%), and two molluscan species groups, Lymnaea spp and Gyraulus spp (2% and 1% respectively), the bulk of the remaining zoobenthic taxa (greater than 1%) were members of the Diptera. The most abundant dipterans collected were Pseudosmittia spp (11%), Cricotopus (cricotopus) cylindraceus (4%), Cricotopus (cricotopus) tremulus (3%) and Orthocladiinae (3%) (Table 3.3.2-1).

The mean densities of the dominant species groups within the oligochaetes and the dipterans (eg, Nais spp and Pseudosmittia spp) increased substantially between the May 27 and September 2 sampling periods. For example the mean density of Nais variabilis increased from 53 organisms/m^2 in May to 627 organisms/m^2 in September. Although the mean densities of some groups, such as Cricotopus spp, did not change appreciably over the same period (May 27 - September 2), the majority of benthic organisms had experienced a decline in abundance by the third sampling period (October 29).

The total densities of benthic fauna collected at each sampling site during each period are presented in Table 3.3.2-2. During the May sampling period densities at the 1 m depth contour ranged from 32/m^2 at transect E to 6 996/m^2 at transect A. The second and third highest densities (2 182/m^2 and 2 150/m^2) occurred on the BHWP and Douglas Point discharge transects (C & E) at the 3 m depth. However, mean densities (of all benthic organisms combined) across transects and depths were not significantly different (Appendix XI). Mean densities generally declined with increasing depth (Table 3.3.2-2).

Several spar locations could not be sampled during the September sampling session due to rough weather. Consequently analysis of variance of the densities obtained could not be effected. Nevertheless, Table 3.3.2-2 shows clearly that zoobenthic densities were highest in September, with values ranging from 0/m^2 at the 1 m depth on transect A (Lagoon Bay) to 11 393/m^2 at the 7 m transect along the BHWP discharge transect. The latter density value caused the mean density for the transect (C) to be high (6 475/m^2) compared to mean densities at other transects. Mean densities were similar over depth contours (Table 3.3.2-2).

Total densities obtained during the October sampling period ranged from 32/m^2 at 7 m on transect A and 5 and 7 m on transect D, to 5 552/m^2 at 1 m on transect D. Significantly more benthic invertebrates were located inshore at 1 m depth (mean density = 1 893/m^2) than at other depths (Appendix XI). Mean densities were not signficantly different over transects.

Densities of benthic macroinvertebrates were quite low (64/m^2) at the 1 m depth contour of transect C during October, compared with densities at all other transects at the same depth contour (Table 3.3.2-2). A thermal plume was in evidence at the BHWP discharge transect C in October, when a thermal gradient existed

TABLE 3.3.2-1

MEAN DENSITIES (#/m^2) AND PER CENT COMPOSITION OF
DOMINANT MACROINVERTEBRATE TAXA (1% OR MORE OF TOTAL)
BHWP - 1981

	May 27		September 2		October 29		Year	
	Mean Density (#/m^2)	%	Mean Density* (#/m^2)	%	Mean Density (#/m^2)	%	Mean Density (#/m^2)	%
Nais pardalis	210	30	928	33	77	12	405	28
Nais variabilis	53	8	627	22	121	19	267	19
Pseudosmittia spp	25	4	373	13	84	13	161	11
Nais simplex	81	12	76	3	123	19	93	8
Cricotopus (cricotopus) cylendraceus	40	6	47	2	65	10	51	4
Cricotopus (cricolopus) tremulus	58	8	53	2	-	-	37	3
Orthocladiinae	12	2	84	3	17	3	37	3
Paratanytarsus spp	9	1	52	2	38	6	33	2
Tubificidae	4	<1	78	3	20	3	33	2
Lymnaea spp	7	1	81	3	6	1	31	2
Psectrocladius nr simulan	21	3	44	2	-	-	22	2
Vejdovskyiella comata	4	<1	66	2	-	-	22	2
Gyraulus spp	11	2	48	2	5	<1	21	1
Parakiefferiella spp	21	3	19	<1	8	1	16	1
Thienemannimyia group	16	2	19	<1	6	1	14	1
Total %		83		93		88		89

* Mean density values for September are inflated because 11 spar locations could not be sampled.

TABLE 3.3.2-2

TOTAL DENSITIES (#/m^2) OF BENTHIC FAUNA COLLECTED AT EACH SAMPLING SITE DURING MAY, SEPTEMBER AND OCTOBER BHWP - 1981

Month	Contour Depth (m)	TRANSECT A	B	C	D	E	F	G	Row Mean
May	1	6 996	802	128	449	32	96	193	1 242
	3	610	0	2 182	321	2 150	641	546	921
	5	578	160	193	706	1 027	353	417	491
	7	417	289	417	449	353	449	1 412	541
	12	160	32	385	257	642	289	193	280
	Mean	1 752	417	661	436	841	366	552	718
Sept	1	0	-	5 552	-	-	-	-	2 776
	3	2 696	-	-	3 498	1 958	1 958	2 310	2 484
	5	-	-	4 910	1 155	2 471	4 942	3 434	3 382
	7	1 508	-	11 393	2 696	1 316	1 412	1 893	3 370
	12	1 027	-	4 044	2 439	1 958	2 920	481	2 145
	Mean	1 308	-	6 475	2 447	1 926	2 808	2 030	2 832
Oct	1	2 567	834	64	5 552	1 605	1 765	866	1 893
	3	834	128	160	128	513	417	449	376
	5	225	610	64	32	353	513	1 027	403
	7	32	385	674	32	513	417	64	303
	12	64	834	96	64	225	96	193	225
	Mean	745	558	212	1 162	642	642	520	640

from the 1 m depth contour to the 12 m depth contour (17.0° to 9.9°C) (Tables 3.1.1-1 and 3.1.1-3). Quantities of total sulphide measured in the plume at the 1 m and 3 m depth contours (surface and bottom measurements at the 3 m depth contour) approached 15-16 µg/L during October (Table 3.2.1-1). By comparison, a thermal gradient (19.2°C to 9.0°C) indicative of a thermal plume was also present at the Douglas Point discharge transect E, however total sulphide was virtually undetectable at the 1 m and 3 m depth contours, and densities of benthic macroinvertebrates were high (1 605/m^2) (Tables 3.1.1-1, 3.1.1-3, 3.2.1-1 and 3.3.2-2).

Although these data may suggest that the presence of total sulphide in a thermal plume influences the inshore density of benthic macroinvertebrates, data for the May sampling period do not support this conclusion. In May densities of benthic organisms were low at the 1 m and 3 m depth contour of both transects C and E (128/m^2 and 32/m^2, respectively), where thermal gradients were moderate and total sulphide levels did not exceed 6 mg/L. However high densities of benthic organisms were recorded at the 3 m depth contour of transects C and E (2 182/m^2 and 2 150/m^2, respectively), despite a total sulphide level near 10 µg/L (Tables 3.1.1-1, 3.1.1-3, 3.2.1-1 and 3.3.2-2). The lack of data for various locations in September, and the unavailability of total sulphide levels and temperature readings which correspond to the September sampling session, preclude any discussion of zoobenthos densities in September relative to a thermal-H_2S plume.

Overall these results are inconclusive with respect to the influence of the BHWP thermal-H_2S plume on the densities of benthic macroinvertebrates in the nearshore zone. Greatest zoobenthos densities were recorded during September.

Ecological Diversity

Two measures of ecological diversity were derived for zoobenthos collections made during each sampling period: the number of taxa (species richness), and the Shannon-Wiener index (species evenness) (Tables 3.3.2-3 and 3.3.2-4). Seasonal differences existed in the number of taxa recorded. The maximum average number of taxa (13) occurred during September, followed by May (7) and October (5). The thermal-H_2S discharge along transect C and the thermal discharge along transect E probably did not strongly influence the number of benthic invertebrate taxa found in the nearshore area since there was no evidence (during May or October) of a relationship between bottom sulphide concentrations and temperatures affecting the survey area and numbers of taxa. Even at the 1 m depth contour of transect C, where elevated temperatures and sulphide levels could reasonably be expected to influence the benthic fauna, numbers of taxa were not very different from those recorded at greater depths (Table 3.3.2-3).

Values of the Shannon-Wiener diversity index are shown in Table 3.3.2-4. Small values are indicative of low species diversity. Two factors determine the diversity index: (1) number of species (here taxa) and (2) evenness of distribution of individuals among the species groups. Shannon-Wiener diversity values therefore increase as the number of taxa increase, and as the

TABLE 3.3.2-3

TOTAL NUMBERS OF ZOOBENTHIC TAXA
COLLECTED AT EACH LOCATION
BHWP - 1981

MAY								
Contour Depth (m)	TRANSECT							Mean
	A	B	C	D	E	F	G	
1	18	7	3	5	1	3	3	6
3	8	0	7	8	15	15	7	9
5	11	3	5	11	11	7	6	8
7	7	6	7	11	7	10	14	9
12	4	1	6	7	12	9	3	6
Mean	10	3	6	8	9	9	7	7

SEPTEMBER								
Contour Depth (m)	TRANSECT							Mean
	A	B	C	D	E	F	G	
1	0	-	14	-	-	-	-	7
3	14	-	-	12	12	12	9	12
5	-	-	12	12	19	20	16	16
7	11	-	22	21	16	13	16	17
12	4	-	12	12	15	14	10	11
Mean	7	-	15	14	16	15	13	13

OCTOBER								
Contour Depth (m)	TRANSECT							Mean
	A	B	C	D	E	F	G	
1	10	9	2	15	5	9	6	8
3	11	4	3	3	6	7	8	6
5	5	12	2	1	3	5	6	5
7	1	7	5	1	9	3	2	4
12	2	10	3	2	5	3	3	4
Mean	6	8	3	4	6	5	5	5

TABLE 3.3.2-4

SPATIAL AND TEMPORAL DISTRIBUTION OF DIVERSITY
VALUES (SHANNON-WIENER) FOR BENTHIC FAUNA COLLECTED AT BHWP - 1981

Month	Contour Depth (m)	TRANSECT							Depth Contour Mean
		A	B	C	D	E	F	G	
May	1	2.01	2.05	1.50	2.18	0.00	1.59	1.46	1.46
	3	2.72	0.00	1.59	2.92	2.91	3.75	2.54	2.35
	5	3.24	1.52	2.25	3.26	2.95	2.66	2.29	2.60
	7	2.50	2.28	2.62	3.32	2.55	3.09	3.22	2.80
	12	1.92	0.00	2.42	2.75	3.41	3.17	1.46	2.16
	Trans Mean	2.48	1.17	2.08	2.89	2.36	2.85	2.19	
Sept	1	0.00	-	2.13	-	-	-	-	1.07
	3	2.53	-	-	2.71	2.77	2.79	2.37	2.63
	5	-	-	2.32	2.98	3.18	2.80	2.31	2.72
	7	2.45	-	2.13	3.34	3.35	2.99	3.32	2.93
	12	1.16	-	2.20	2.78	2.99	2.74	2.80	
	Trans Mean	1.54	-	2.20	2.78	2.99	2.74	2.80	
Oct	1	2.21	2.48	1.00	2.67	1.39	2.41	1.90	2.01
	3	3.26	2.00	1.37	1.50	2.43	2.50	2.56	2.23
	5	2.13	3.43	1.00	0.00	1.35	1.92	1.97	1.69
	7	0.00	2.75	1.67	0.00	2.85	1.42	1.00	1.38
	12	1.00	2.93	1.59	1.00	2.13	1.59	1.59	1.69
	Trans Mean	1.72	2.72	1.33	1.03	2.03	1.97	1.80	

number of individuals per species group becomes more equitable (Krebs, 1972). No firm spatial or temporal pattern of distribution of diversity values was noted. The substantial variation in values, which ranged between 0.00 and 3.75, indicates that species diversity was quite variable from location to location (Table 3.3.2-4). Diversity was lowest along transect B in May (mean diversity index = 1.17), and transects C and D in October (mean diversity indices = 1.33 and 1.03 respectively). The low mean number of taxa observed along the above three transects probably accounts for the correspondingly low diversity indices.

Spatial Variability of Dominant Benthic Invertebrates

The spatial distributions of seasonal (ie, averaged over three sampling periods) densities of the four most abundant benthic invertebrates are compared in Table 3.3.2-5. Nais pardalis, the most prevalent oligochaete, was concentrated along the BHWP discharge transect (mean density = 1134/m^2). This was in sharp contrast to the adjacent transects (B and D), where mean densities were only 42/m^2 and 259/m^2. This species was only present at shallow depths (1 m) along transect B. Transects farther away from the BHWP discharge had mean densities of Nais pardalis ranging from 75/m^2 at transect G to 328/m^2 at transect A, where a rather high density (1 583/m^2) of these organisms was recorded at the 1 m depth. The greatest seasonal density per location occurred at the 7 m depth contour of transect C (2 471/m^2).

A more even distribution of densities of Nais variabilis was observed. Densities ranged between 0/m^2 at the 3 m depth of transect B to 754/m^2 at the 1 m depth of transect D. Transect B was associated with the lowest mean density of Nais variabilis (51/m^2) while transect G supported the greatest mean density of this species (281/m^2). Mean density declined with increasing depth, and the value at the 1 m depth contour (324/m^2) was 2.5 times that at the 12 m depth contour.

Pseudosmittia spp was third in overall abundance at BHWP. Table 3.3.2-5 shows that this species group exhibited a variable seasonal density distribution pattern. Generally, the 3, 5 and 7 m depth contours supported the greatest densities of Pseudosmittia spp, while the highest densities along transects A and B occurred at the 12 m depth contour. The maximum seasonal density was found at 7 m along transect C (406/m^2). Mean density of Pseudosmittia spp was lowest along transect B (42/m^2) and greatest along transect A (173/m^2). Across depth contours, the 7 m depth contour had the highest mean density (194/m^2).

Nais simplex was most prominent in the shallower depths with mean densities across the 1 m and 3 m depth contours of 349/m^2 and 114/m^2 respectively. At the 12 m depth contour, the mean density was only 9/m^2. This pattern of decreasing mean density with greater depth was more pronounced for Nais simplex than for N. variabilis. Transects A and B both supported the lowest mean

TABLE 3.3.2-5

SPATIAL VARIATION IN DENSITIES (#/m^2)
OF FOUR DOMINANT ZOOBENTHIC TAXA COLLECTED AT BHWP - 1981

Taxa	Contour Depth (m)	TRANSECT							Depth Contour Mean
		A	B	C	D	E	F	G	
Nais pardalis	1	1583	209	1027	963	0	48	32	552
	3	21	0	546	64	310	160	246	192
	5	16	0	888	0	64	685	0	236
	7	0	0	2471	182	53	128	32	409
	12	21	0	738	86	214	556	64	240
	Trans Mean	328	42	1134	259	128	315	75	326
Nais variabilis	1	546	112	439	754	128	209	80	324
	3	492	0	48	513	139	278	300	253
	5	48	32	182	86	267	300	685	229
	7	160	16	193	289	21	32	321	147
	12	43	96	332	64	267	75	21	128
	Trans Mean	258	51	239	341	164	179	281	216
Pseudo-smittia spp	1	225	16	43	80	0	32	16	59
	3	182	16	0	86	257	96	160	114
	5	32	32	214	128	257	374	321	194
	7	160	32	406	75	203	225	139	177
	12	268	112	64	11	32	86	11	83
	Trans Mean	225	42	146	76	150	163	129	125
Nais simplex	1	225	305	96	578	562	385	289	349
	3	32	16	481	11	150	0	107	114
	5	48	16	86	21	64	21	0	37
	7	96	32	75	0	11	21	118	50
	12	0	32	0	11	0	21	0	9
	Trans Mean	80	80	148	124	157	90	103	112

density ($80/m^2$) while the highest mean density of N. simplex occurred at transect E. The maximum seasonal density along transect C was found at 3 m ($481/m^2$).

Density values (for each major taxon) at the BHWP and Douglas Point discharges were subjected to statistical analysis using the nonparametric Mann-Whitney U Test (Siegel, 1956). Only in one case, for Nais pardalis, were densities in the BHWP discharge area significantly greater than densities in the Douglas Point discharge area ($P = 0.004$). Although this result reflects a greater concentration of N. pardalis in areas directly influenced by the BHWP thermal-H_2S plume, this phenomenon did not occur for N. variabilis, N. simplex or Pseudosmittis spp, suggesting that the effect may not be general for benthic organisms inhabiting the BHWP nearshore zone. Observed distributions of the latter three taxa are probably a reflection of natural distribution patterns. No biological significance can be attached to the statistical difference identified for N. pardalis, since this oligochaete is known to occur in both the BHWP and Douglas Point discharges in relatively high densities (OHRD Report 82-107-K).

Distribution of Zoobenthic Assemblages

The application of Mutual Information Analysis (Orloci, 1969) has proved useful in the description of benthic aquatic communities (Ontario Hydro Research Division Report 75-446-K). The technique involves the grouping together of samples which have similar diversity indices and taxonomic composition. Six assemblages were identified for the BHWP zoobenthos data (Table 3.3.2-6). Assemblage 1 was dominated by Nais paradalis, assemblage 3 by Pseudosmittia spp, assemblage 4 by Nais simplex, assemblage 5 by Vejdovskyiella comata, and assemblage 6 by Nais variabilis. Assemblage 2 contained approximately equal proportions of the major species groups, and was probably created by grouping together species which had very low representation in the total data set.

The spatial and temporal distribution of these assemblages is presented in Table 3.3.2-7. Assemblage 2 was the most widely distributed assemblage, and occurred in 46 of 94 samples, being prevalent in May and October. Assemblage 1 (with N. pardalis dominant) occurred mainly during September along transect C, a result which is consistent with the high densities of this species found along transect C (Table 3.3.2-5). Assemblage 6 (dominated by N. variabilis) was chiefly restricted to the 3 m, 5 m and 7 m depths of transects A, D, E and G during September. The benthic assemblage containing the highest percentage of N. simplex (assemblage 4) was absent from the September samples and was confined to the shallow (1 m and 3 m) lakeshore areas along transects B, D and G in both May and October, and along transects A, B, E, F and G in October only. Transect C was the single transect from which assemblage 4 was completely absent. Assemblage 3, in which Pseudosmittia spp formed the major species group, was common in October at the 3 m to 7 m depth con-

TABLE 3.3.2-6

PER CENT COMPOSITION OF ZOOBENTHIC ASSEMBLAGES
BHWP - 1981

Species	Assemblages					
	1	2	3	4	5	6
Nais pardalis	66	8	5	11	11	2
Nais variabilis	4	5	8	18	8	41
Pseudosmittia spp	8	7	30	3	0	15
Nais simplex	3	5	3	43	0	8
Cricotopus (cricotopus) cylendraceus	1	9	14	5	0	4
Cricotopus (cricotopus) tremulus	0	10	1	3	0	2
Vejdovskyiella comata	0	1	0	0	62	0

TABLE 3.3.2-7

SPATIAL AND TEMPORAL DISTRIBUTION OF ZOOBENTHIC ASSEMBLAGES
BHWP - 1981

Month	Contour Depth (m)	TRANSECT						
		A	B	C	D	E	F	G
May	1	1	4	2	4	2	2	4
	3	2	2	1	2	1	4	4
	5	2	2	2	2	3	2	2
	7	2	2	2	2	2	2	6
	12	2	2	3	2	2	2	2
Sept	1	2	-	1	-	-	-	-
	3	6	-	-	6	3	2	2
	5	-	-	1	3	6	1	6
	7	6	-	1	2	3	3	6
	12	3	-	1	5	2	1	2
Oct	1	6	4	2	1	4	4	4
	3	3	2	2	2	3	3	3
	5	4	3	2	2	3	3	3
	7	2	3	3	2	3	3	2
	12	2	3	2	3	2	2	2

tours, especially on transects B, E, F and G. The few occurrences of assemblage 3 in May and September were at a depth of 3 m or greater. The single location where assemblage 5 occurred was at the 12 m depth of transect D during September.

The results of the Mutual Information Analysis showed that of the 6 assemblages noted, only assemblage 2 exhibited widespread distribution, particularly during May and October. This result supports the earlier conclusion that the composition and distribution of benthic fauna in the nearshore region adjacent to BHWP is extremely variable.

The exclusive occurrence of assemblage 1 (dominated by N. pardalis) in the BHWP discharge during September provides additional evidence of the concentration of the oligochaete N. pardalis in the BHWP discharge area. It is possible that warm water released into the discharge area is influencing the distribution of this species since high densities of N. pardalis have also been reported in the Bruce GS 'A' discharge (OHRD Report 82-107-K), which, unlike the BHWP discharge, is not associated with potential hydrogen sulphide release to the aquatic environment. Further detailed study would be required to confirm this phenomenon.

3.3.3 Adult and Juvenile Fish

Species Composition and Abundance

A total of 4,267 fish representing 25 species were taken, with the relative contribution of fish in gill nets and trap nets being 93 and 7%, respectively (Table 3.3.3-1). Alewife dominated the fish catch, accounting for 62% of the total catch. Other common species taken, in decreasing order of abundance, included longnose sucker (14%), white sucker (7%), gizzard shad (3%), round whitefish (2%) and walleye (2%). Collectively, these six species comprised 90% of the total fish catch.

The total fish catch was distributed rather evenly among the four sampling locations, with 866 fish (22%) captured at Macpherson Bay (transect A), 1043 fish (27%) caught near the BHWP discharge (transect C), 995 fish (25%) caught near the Douglas Point discharge (transect E), and 1051 fish (27%) netted at Lagoon Bay (transect G). The largest number of species (20) was taken near the Douglas Point discharge, while 18, 17 and 17 different species were collected along transects A, C and G, respectively (Table 3.3.3-2).

Gill net fishing produced a total of 3955 fish (93%) compared with 312 fish (7%) collected by trap net fishing. The wide discrepancy in fish catch by gear type can be partially attributed to the use of twice as many gill nets (16) as trap nets (8). Further, gill nets were set at both surface and bottom locations in deep and shallow waters, whereas trap nets were only set in shallow shoreline areas.

White sucker was the most abundant fish species caught by trap net (92 fish or 30%), followed by longnose sucker (77 fish or 25%) and alewife (66 fish or 21%). Alewife accounted for 66% of the total gill net catch, while longnose sucker and white sucker comprised 13% and 5% of the total gill net catch, respectively.

Overall greater numbers of fish were caught in bottom gill net sets than in surface gill net sets (Appendix V). Species such as longnose sucker, white sucker and round whitefish are bottom-feeders (Scott and Crossman, 1973) and thus would be expected to predominate in bottom gill net catches. Alewife and gizzard shad are pelagic species and consequently occur in both surface and bottom gill net catches. Walleye often swim in schools near the lake bottom, and are therefore susceptible to bottom gill net fishing (Appendix V).

Spatial and Temporal Variability of Fish Catch

Alewife

The largest concentration of alewife was found along the Douglas Point discharge transect where the mean catch per unit effort (CUE) for total gill net fishing was 30.79 (Table 3.3.3-3). Alewife were relatively abundant at other sampling sites, with mean CUE values ranging from 29.42 at Lagoon Bay, to 24.91 at the BHWP discharge and 23.13 at Macpherson Bay. Bottom gill net catches of alewife were distributed in the same order with respect to the four sampling locations, however mean CUE values for surface gill net sets were highest at BHWP discharge (26.17) and lowest at Lagoon Bay (11.25) (Appendix V).

Alewife trap net catches were maximal in Lagoon Bay and Douglas Point discharge where mean CUE values were 2.58 and 1.92 fish per trap net set, respectively (Table 3.3.3-4). Peak abundance of alewife occurred in May at all sampling locations, and was probably associated with the alewife spawning migration (Scott and Crossman, 1973). Catch per unit effort had declined substantially by the end of August and no alewife were caught during the October sampling period. These temporal differences in CUE were statistically significant (Appendix VI).

Longnose Sucker

Longnose sucker was second in abundance to alewife, however most suckers were caught in bottom gill net sets (Appendix V). Maximum numbers of longnose suckers were collected in the BHWP discharge area (mean CUE = 6.54), followed by Lagoon Bay (6.25), Douglas Point discharge (4.59) and Macpherson Bay (4.33) (Table 3.3.3-3). Highest seasonal catches were recorded in May at all sampling sites and corresponded to the spawning period of longnose sucker. Catches had decreased in all locations by August, but fish were still being netted in late October, with mean CUE values ranging from a high of 4.13 at BHWP discharge to 1.38 at Macpherson Bay (Table 3.3.3-3). Analysis of variance and multiple comparison testing indicated that mean monthly CUE values for August and October were not significantly different

TABLE 3.3.3-1

SPECIES COMPOSITION AND NUMBERS OF FISH COLLECTED BY EACH GEAR TYPE - BHWP, 1981

Fish Species	Trap Net		Gill Net		Totals	
	Total Caught	% Composition	Total Caught	% Composition	Total Caught	% Composition
Alewife	66	21.2	2598	65.7	2664	62.4
Longnose Sucker	77	24.7	521	13.2	598	14.0
White Sucker	92	29.5	208	5.3	300	7.0
Gizzard Shad	1	0.3	136	3.4	137	3.2
Round Whitefish	3	1.0	91	2.3	94	2.2
Walleye	1	0.3	81	2.0	82	1.9
Yellow Perch	2	0.6	77	1.9	79	1.9
Lake Chub	5	1.6	58	1.5	63	1.5
Golden Redhorse	12	3.8	41	1.0	53	1.2
Channel Catfish	2	0.6	49	1.2	51	1.2
Burbot	1	0.3	45	1.1	46	1.1
Smallmouth Bass	34	10.9	8	0.2	42	1.0
Rock Bass	14	4.5	1	<0.1	15	0.4
Rainbow Trout	1	0.3	12	0.3	13	0.3
Rainbow Smelt	1	0.3	5	0.1	6	0.1
Splake	0	0.0	4	0.1	4	0.1
Spottail Shiner	0	0.0	4	0.1	4	0.1
Carp	0	0.0	3	0.1	3	<0.1
Coho Salmon	0	0.0	3	0.1	3	<0.1
Freshwater Drum	0	0.0	4	0.1	4	0.1
Chinook Salmon	0	0.0	2	0.1	2	<0.1
Brown Trout	0	0.0	1	<0.1	1	<0.1
Emerald Shiner	0	0.0	1	<0.1	1	<0.1
Northern Pike	0	0.0	1	<0.1	1	<0.1
Trout-Perch	0	0.0	1	<0.1	1	<0.1
Totals	312		3955		4267	
(%)	(7.31)		(92.69)			
(Number of Species)	(13)		(25)		(25)	

TABLE 3.3.3-2

SPECIES COMPOSITION AND NUMBERS OF FISH COLLECTED AT EACH SAMPLING LOCATION - BHWP, 1981

Fish Species	MacPherson Bay		BHWP Discharge		Douglas Point		Lagoon Bay	
	Total Caught	%	Total Caught	%	Total Caught	%	Total Caught	%
Alewife	555	64.1	598	57.3	739	74.3	706	67.2
Longnose Sucker	104	12.0	157	15.1	110	11.1	150	14.3
White Sucker	48	5.5	59	5.7	52	5.2	49	4.7
Gizzard Shad	58	6.7	61	5.8	12	1.2	5	0.5
Round Whitefish	20	2.3	28	2.7	15	1.5	28	2.7
Walleye	36	4.2	30	2.9	6	0.6	9	0.9
Yellow Perch	6	0.7	33	3.2	3	0.3	35	3.3
Lake Chub	5	0.6	14	1.3	18	1.8	21	2.0
Golden Redhorse	9	1.0	22	2.1	5	0.5	5	0.5
Channel Catfish	11	1.3	12	1.2	7	0.7	19	1.8
Burbot	5	0.6	15	1.4	12	1.2	13	1.2
Smallmouth Bass	0	0.0	8	0.8	0	0.0	0	0.0
Rock Bass	0	0.0	0	0.0	0	0.0	1	0.1
Rainbow Trount	2	0.2	1	0.1	5	0.5	4	0.4
Splake	0	0.0	2	0.2	2	0.2	0	0.0
Spottail Shiner	0	0.0	0	0.0	3	0.3	1	0.1
Carp	1	0.1	1	0.1	1	0.1	0	0.0
Coho Salmon	1	0.1	0	0.0	1	0.1	1	0.1
Freshwater Drum	1	0.1	1	0.1	1	0.1	1	0.1
Chinnook Salmon	2	0.2	0	0.0	0	0.0	0	0.0
Brown Trout	1	0.1	0	0.0	0	0.0	0	0.0
Emerald Shiner	0	0.0	0	0.0	1	0.1	0	0.0
Northern Pike	1	0.1	0	0.0	0	0.0	0	0.0
Trout-Perch	0	0.0	0	0.0	1	0.1	0	0.0
Totals	866		1043		995		1051	
(%)	(21.90)		(26.37)		(25.16)		(26.57)	
(Number of Species)	(18)		(17)		(20)		(17)	

from one another, but were significantly smaller than the May CUE value (Appendix VI). A maximum of 3.00 fish per trap net set was recorded at BHWP discharge for the three time periods (Table 3.3.3-4).

White Sucker

White sucker catches were lower than those of longnose sucker. Mean CUE values for fish caught in gill nets ranged between 1.92 at Douglas Point discharge to 2.59 at BHWP discharge. White sucker catches were generally highest in August, except at Douglas Point discharge, where the maximum gill net CUE (3.00) occurred in May (Table 3.3.3-3). There were no significant spatial or temporal differences among the white sucker CUE data (Appendix VI). Trap net fish catches were small with the greatest mean CUE recorded at BHWP discharge in May (9.50) (Table 3.3.3-4).

Trap net catches were generally low at all locations sampled. Application of the Mann-Whitney U Test to the mean CUE data for fish caught by trap net at the BHWP and Douglas Point discharges indicated that no significant differences existed between fish catches at the two areas ($p = 0.2$).

The spring alewife - longnose sucker - white sucker species complex identified in this study was common to the Douglas Point, South Boundary and Macpherson Bay areas sampled during the 1973-1975 BNPD preoperational aquatic surveys (Ontario Hydro Research Division Report 80-291-K). Although the BHWP discharge was not sampled during preoperational surveys the fish composition at BHWP seems to be consistent with that of the adjacent shoreline areas. Gill net catches from the 1979 and 1980 BNPD post-operational surveys reflected the dominance in spring of alewife, longnose sucker and white sucker.

Three-way analysis of variance (location x month x year) comparing the 1979 and 1980 BNPD post-operational survey gill net data and the present BHWP gill net data (for common sampling locations and months) showed that mean CUE values for alewife and longnose sucker differed significantly between months for each year of aquatic survey (Appendix VII). The Student-Newman-Keuls multiple comparison test demonstrated that for both alewife and longnose sucker, May CUE values were significantly greater than August or October values, which were not significantly different. White sucker mean monthly CUE values were not significantly different, although significant interactions existed between location and year, and month and year (Appendix VII).

These results are indicative of a characteristic alewife - longnose sucker - white sucker species complex which attains numerical dominance during the spring (May in this study) in the nearshore zone between Macpherson Bay and Douglas Point generating station. Previous studies have shown that these same three fish form the dominant species along the Lake Huron shoreline from Sand Bay in the north to Gunn Point in the south (Ontario Hydro Research Division Reports 82-107-K and 82-109-K).

TABLE 3.3.3-3

CATCH PER UNIT EFFORT (CUE) OF DOMINANT SPECIES COLLECTED BY GILL NET DURING MAY, AUGUST AND OCTOBER - BHWP, 1981

Species	Month	MacPherson Bay	BHWP Discharge	Douglas Point Discharge	Lagoon Bay	Monthly Means
Alewife	M	50.25	51.63	67.63	66.00	58.88
	A	19.13	23.13	24.75	22.25	22.31
	O	0.00	0.00	0.00	0.00	0.00
Location Means		23.13	24.91	30.79	29.42	
Longnose Sucker	M	9.88	11.25	8.38	10.75	10.07
	A	1.75	4.25	3.88	5.88	3.94
	O	1.38	4.13	1.50	2.13	2.29
Location Means		4.33	6.54	4.59	6.25	
White Sucker	M	1.38	2.00	3.00	1.25	1.91
	A	2.25	3.63	1.88	3.13	2.72
	O	2.38	1.75	1.63	1.75	1.88
Location Means		1.96	2.59	1.92	2.04	
Gizzard Shad	M	0.25	0.00	0.00	0.00	0.06
	A	0.25	0.00	0.38	0.13	0.19
	O	6.75	7.63	1.13	0.50	4.00
Location Means		2.42	2.54	0.50	0.21	
Round Whitefish	M	0.13	0.75	0.88	0.88	0.66
	A	0.13	0.63	0.00	0.00	0.19
	O	2.25	2.13	1.00	2.63	2.00
Location Means		0.84	1.17	0.63	1.17	
Walleye	M	0.00	0.00	0.00	0.00	0.00
	A	0.00	0.13	0.00	0.00	0.03
	O	4.50	3.63	0.75	1.13	2.50
Location Means		1.50	1.25	0.25	0.38	

TABLE 3.3.3-4

CATCH PER UNIT EFFORT (CUE) OF DOMINANT SPECIES COLLECTED BY TRAP NET DURING MAY, AUGUST AND OCTOBER - BHWP, 1981

Species	Month	MacPherson Bay	BHWP Discharge	Douglas Point Discharge	Lagoon Bay
Alewife	M	0.50	2.50	5.75	7.75
	A	0.00	0.00	0.00	0.00
	O	0.00	0.00	0.00	0.00
	Means	0.17	0.83	1.92	2.58
Longnose Sucker	M	4.75	8.50	2.00	2.25
	A	0.00	0.50	0.50	0.75
	O	0.00	0.00	0.00	0.00
	Means	1.58	3.00	0.83	1.00
White Sucker	M	1.50	9.50	2.25	1.25
	A	0.75	3.75	1.75	1.50
	O	0.50	0.25	0.25	0.00
	Means	0.92	4.50	1.42	0.92
Redhorse Sucker	M	0.00	0.00	0.50	0.00
	A	0.00	1.75	0.25	0.00
	O	0.50	0.00	0.00	0.00
	Means	0.17	0.58	0.25	0.00
Smallmouth Bass	M	0.00	0.00	0.00	0.25
	A	0.25	5.00	3.00	0.00
	O	0.00	0.00	0.00	0.00
	Means	0.08	1.68	1.00	0.08
Rock Bass	M	0.25	0.00	0.25	0.25
	A	0.25	1.75	0.25	0.00
	O	0.00	0.00	0.00	0.00
	Means	0.17	0.58	0.17	0.08

Table 3.3.3-5 presents total surface gill net catches at BHWP together with surface total sulphide determinations made on the same day, during May, August and October. There are no consistent trends in the data which suggest a relationship between ambient sulphide levels and fish abundance near the surface. For transect C (BHWP discharge), consecutive surface gill net sets at the 3 m depth contour yielded 110 and 98 fish each, coincident with sulphide concentrations ranging between 8 to 11 µg/L. At Macpherson Bay where low sulphide levels were consistently recorded (<2 µg/L), numbers of fish caught ranged from 0 at the 12 m depth on October 26-27 to 85 on May 25-26 at the 3 m depth. Results of Mann-Whitney U Tests showed that fish catches made at BHWP and Douglas Point discharges on the May, August and October sampling dates were not significantly different from one another ($0.17 < p < 0.44$).

Table 3.3.3-6 illustrates the lack of relationship between bottom total sulphide levels and fish abundance at depth along the BHWP discharge transect. Fish catches made during August at the 3 and 12 m depth contours were not substantially different from May catches, although October catches were lower than those of either May or August. Bottom gill net catches at the 3 m depth contour were similar to 12 m depth catches in both May and August despite differences in total sulphide concentrations. In October 3 m depth contour catches greatly exceeded those made at the 12 m depth contour, although sulphide levels were higher at the shallower depth contour (Table 3.3.3-6). Examination of plume configurations (Figures 3.1.2-1 to 3.1.2-3) with respect to fish distribution in the BHWP area (Tables 3.3.3-5 and 3.3.3-6) did not reveal a pattern which may have resulted from shifts in plume configuration. Larger numbers of fish were often captured in shallow water (3 m depth contour) rather than in deep water (12 m depth contour) along the BHWP and Douglas Point discharge transects, however the trend was not consistent.

4.0 SUMMARY

4.1 Physical Characteristics

Along the 3 m depth contour elevated surface water temperatures occurred in the BHWP discharge area during May and October, and in the Douglas Point discharge area during August. No thermal gradient existed among locations along the 12 m depth contour, where surface water temperatures were generally lower than those at the 3 m depth contour. The maximum ΔT between surface temperatures at the 1 m and 12 m depth contours was 8.3°C and occurred during October along the Douglas Point discharge transect.

Recorded bottom water temperatures did not exceed 24.7°C and except for the October sampling period, declined sharply with increasing depth. The bottom temperature data provided further evidence of the existence of BHWP and Douglas Point thermal plumes, which did not appear to extend (along the bottom) beyond the 3 m depth contour.

TABLE 3.3.3-5

COMPARISON OF SURFACE GILL NET CATCHES AND TOTAL SULPHIDE RANGES* AT GILL NET LOCATIONS - BHWP, 1981

Depth Contour (m)		Month											
		Transect				Transect				Transect			
		A	C	E	G	A	C	E	G	A	C	E	G
		May 25 to 26				August 25 to 26				October 26 to 27			
3	Sulphide	<2	8-10	<2-5	<2	<2	<2	<2	<2	<2	13-15	<2-2	<2-2
	No of Fish	85	110	6	15	3	5	2	1	6	4	6	0
12	Sulphide	<2	<2	<2	<2	<2	<2	<2	<2	<2	2-5	<2-2	<2
	No of Fish	1	2	35	44	25	26	9	3	0	1	1	1
		May 26 to 27				August 26 to 27				October 26 to 28			
3	Sulphide	<2	10-11	<2	<2	<2	<2	<2	<2	<2	12-15	2	<2-2
	No of Fish	59	98	86	19	7	3	13	1	8	31	3	2
12	Sulphide	<2	<2	<2	<2	<2	<2	<2	<2	<2-2	<2-2	2-3	<2
	No of Fish	7	62	1	43	5	10	1	12	7	0	1	2

* Sulphide measured at surface as $\mu g\ L^{-1}$.

TABLE 3.3.3-6

COMPARISON OF BOTTOM GILL NET CATCHES AND TOTAL SULPHIDE RANGES* AT THE BHWP DISCHARGE (TRANSECT C) - BHWP, 1981

Depth Contour (m)		Month					
		May		August		October	
		25 to 26	26 to 27	25 to 26	26 to 27	26 to 27	27 to 28
3	Sulphide	<2-10	<2-10	<2-10	<2-3	2-16	4-26
	No of Fish	48	97	112	26	54	30
12	Sulphide	<2	<2	<2	<2	<2-2	<2-2
	No of Fish	81	62	21	115	23	22

* Sulphide measured at bottom as $\mu g\ L^{-1}$.

Calculated thermal-H_2S plume configurations were strongly influenced by the speed and direction of alongshore current systems. Consequently the plume model is likely to be less accurate when rapid changes in current characteristics occur. The present study identified several instances when measurable sulphide concentrations occurred outside of predicted plume configurations.

4.2 Chemical Characteristics

The maximum total sulphide value recorded (16 µg/L) and generally occurred inside the 1 m depth zone of BHWP discharge. Total sulphide concentrations declined rapidly with depth and were not detectable in bottom water samples beyond the 5 m depth contour.

4.3 Biological Characteristics

4.3.1 Attached Algae

Fifteen taxa of attached algae and three of epiphytic algae were collected at the BHWP shoreline locations during May, August and October. Attached algae distribution was extremely variable over the entire sampling area and no consistent trends were identified although Ulothrix zonata was prominent in May and October. Similarly mean attached algae biomass varied substantially among the shoreline locations and over sampling periods. The maximum algal standing crop (53.51 g/m^2) occurred in BHWP discharge during October, but did not differ significantly from standing crops observed at other locations.

4.3.2 Zoobenthos

Oligochaetes (mainly Naididae) and dipterans dominated the extremely diverse benthic fauna. Numbers of organisms generally declined with increasing depth. Densities of benthic organisms were highest in September.

The maximum number of taxa (13) were found during September, and Shannon-Wiener diversity indices exhibited extreme temporal and spatial variation.

On the basis of combined May, September and October density values, Nais pardalis appeared to be concentrated along the BHWP discharge transect where its mean density was $1134/m^2$.

Mutual Information Analysis identified six zoobenthic assemblages which in general were distributed rather randomly over the sampling area. Assemblage 1, dominated by N. pardalis, occurred most frequently along the BHWP discharge transect.

4.3.3 Adult and Juvenile Fish

A total of 4 267 fish representing 25 species were caught. The total fish catch was dominated by alewife, longnose sucker and white sucker. These three species are typically dominant in the

in-shore region of Lake Huron near Bruce Nuclear Power Development. Greater abundance of alewife and longnose sucker occurred during the spring at all locations sampled.

Differences between fish catches made at BHWP discharge and Douglas Point discharge were not significant ($p > 0.17$).

5.0 CONCLUSIONS

No correlation was found between observed levels of total sulphide in water samples and abundance or distribution of fish, zoobenthos or attached algae.

A high concentration of the oligochaete Nais pardalis in the vicinity of the BHWP discharge may indicate a response to the thermal component of the plume.

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APPENDIX I

ATTACHED ALGAE BIOMASS (g/m^2)
BHWP - 1981

Location	May	August	October	
A Macpherson Bay	7.28 21.32 22.60 17.07 ±8.50	2.68 0.88 0.92 1.49 ±1.03	45.12 22.72 20.00 29.28 ±13.79	15.95 ±14.54
B	2.24 15.00 6.88 8.04 ±6.46	21.24 21.04 7.76 16.68 ±7.73	41.40 27.52 36.60 35.17 ±7.05	19.96 ±13.49
C BHWP discharge	22.40 21.12 16.60 20.04 ±3.05	40.36 20.84 21.40 27.53 ±11.11	12.72 108.52 39.28 53.51 ±49.46	33.69 ±29.60
D	0.00 0.00 0.00 0.00 ±0.00	1.48 1.96 3.44 2.29 ±1.02	7.20 2.40 4.04 4.55 ±2.44	2.28 ±2.37
E Douglas Pt discharge	41.96 48.48 34.24 41.56 ±7.13	29.88 57.40 28.80 38.69 ±16.21	5.76 39.48 22.84 22.69 ±16.86	34.32 ±15.07
F	25.56 24.48 33.00 27.68 ±4.64	22.04 35.84 31.08 29.65 ±7.01	15.92 22.80 25.36 21.36 ±4.88	26.23 ±6.14
G Lagoon Bay	5.32 3.44 1.24 3.33 ±2.04	6.40 10.28 5.80 7.49 ±2.43	3.20 15.04 3.36 7.20 ±6.79	6.01 ±4.25
	16.82 ±14.57	17.69 ±15.59	24.82 ±23.62	

APPENDIX II

ONE-WAY ANALYSIS OF VARIANCE FOR MONTHLY SHORELINE ATTACHED ALGAE BIOMASS, AND RELEVANT MULTIPLE COMPARISON TEST RESULT BHWP - 1981

Analysis of Variance

Month	Calculated F Statistic
May	$**22.48_{[6,14]}$
August	$** 8.93_{[6,14]}$
October	$* 1.94_{[6,14]}$

* Not significant at α 0.05
** Significant at α 0.05

Multiple Comparison Test (Student-Newman-Keuls)

Month	Transect						
May	D	G	B	A	C	F	E
	0.00	3.33	8.04	17.07	20.04	27.68	41.56
August	A	D	G	B	C	F	E
	1.49	2.29	7.49	16.68	27.53	29.65	38.69

APPENDIX III

TWO-WAY ANALYSIS OF VARIANCE OF ATTACHED ALGAE BIOMASS, AND RELEVANT MULTIPLE COMPARISON TEST RESULT BHWP - 1981

Analysis of Variance

Calculated F Statistic

Location	Date	Interaction
$**8.04_{[6,42]}$	$*2.27_{[2,42]}$	$*1.94_{[12,42]}$

* Not significant at $\alpha 0.05$
** Significant at $\alpha 0.05$

Multiple Comparison Test (Student-Newman-Keuls)

Transect

D	G	A	B	F	C	E
2.28	6.00	15.95	19.96	26.23	33.69	34.32

APPENDIX V

CATCH PER UNIT EFFORT (CUE) OF DOMINANT FISH SPECIES COLLECTED BY SURFACE AND BOTTOM GILL NETS DURING MAY, AUGUST AND OCTOBER: BHWP, 1981

		Surface Set				Bottom Set			
Species	Month	Macpherson Bay	BHWP Discharge	Douglas Point Discharge	Lagoon Bay	Macpherson Bay	BHWP Discharge	Douglas Point Discharge	Lagoon Bay
Alewife	May	36.75	67.75	30.50	30.00	63.75	35.50	104.75	102.00
	Aug	9.00	10.75	5.25	3.75	29.25	35.5	44.25	40.75
	Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Location Means		15.25	26.17	11.92	11.25	31.00	23.67	49.67	47.58
Longnose	May	0.25	0.00	0.00	0.00	19.50	22.50	16.75	21.50
Sucker	Aug	0.00	0.00	0.00	0.00	3.50	8.50	7.75	11.75
	Oct	0.00	0.00	0.00	0.00	2.75	8.25	3.00	4.25
Location Means		0.08	0.00	0.00	0.00	8.58	13.10	9.17	12.50
White	May	0.25	0.00	0.00	0.00	2.50	4.00	6.00	2.50
Sucker	Aug	0.00	0.00	0.00	0.00	4.50	7.25	3.75	6.25
	Oct	0.00	0.00	0.00	0.00	4.75	3.50	3.25	3.50
Location Means		0.08	0.00	0.00	0.00	3.92	4.92	4.33	4.08
Gizzard	May	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shad	Aug	0.50	0.00	0.50	0.25	0.00	0.00	0.25	0.00
	Oct	4.25	8.5	1.75	0.00	9.25	6.75	0.50	1.00
Location Means		1.75	2.83	0.75	0.08	3.08	2.25	0.25	0.33
Round	May	0.00	0.00	0.00	0.00	0.25	1.50	1.75	1.75
Whitefish	Aug	0.00	0.00	0.00	0.00	0.25	1.25	0.00	0.00
	Oct	0.00	0.00	0.00	0.00	4.50	4.25	2.00	5.25
Location Means		0.00	0.00	0.00	0.00	1.67	2.33	1.25	2.33
Walleye	May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Aug	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
	Oct	0.00	0.25	0.00	0.25	9.00	7.00	1.50	2.00
Location Means		0.00	0.08	0.00	0.08	3.00	2.42	0.50	0.67

APPENDIX VI

ANALYSIS OF VARIANCE OF CATCH PER UNIT EFFORT (CUE) DATA FOR DOMINANT FISH SPECIES TAKEN IN GILL NETS, AND RELEVANT MULTIPLE COMPARISON TEST RESULTS BHWP - 1981

Analysis of Variance

SPECIES	Calculated F Statistic		
	Location	Date	Interaction
Alewife	$*0.28_{[3,12]}$	$**24.86_{[2,12]}$	$*0.18_{[6,12]}$
Longnose sucker	$*1.10_{[3,12]}$	$**19.27_{[2,12]}$	$*0.32_{[6,12]}$
White sucker	$*0.10_{[3,12]}$	$*0.70_{[2,12]}$	$*0.48_{[6,12]}$

* Not significant at α 0.05
** Significant at α 0.05

Multiple Comparison Test (Student-Newman-Keuls)

Species	May	August	October
Alewife (Overall Mean CUE)	58.87	22.31	0.00
Longnose sucker (Overall Mean CUE)	10.06	3.94	2.28

APPENDIX VII

ANALYSIS OF VARIANCE RESULTS AND APPROPRIATE
MULTIPLE COMPARISON TEST FOR COMPARISON OF ALEWIFE,
LONGNOSE SUCKER AND WHITE SUCKER GILL NET
CATCH PER UNIT EFFORT (CUE) DATA OBTAINED
DURING BNPD 1979 AND 1980, AND BHWP 1981 AQUATIC SURVEYS
BHWP - 1981

Analysis of Variance

SPECIES	Calculated F Statistic					
	Location	Month	Year	Interaction 1 (Location X Month)	Interaction 2 (Location X Year)	(Interaction 3) (Month X Year)
Alewife	$*0.63_{[2,8]}$	$**4.28^{N.B.}_{[2,8]}$	$*0.01_{[2,8]}$	$*0.40_{[4,8]}$	$*1.26_{[4,8]}$	$*0.19_{[4,8]}$
Longnose sucker	$*0.97_{[2,8]}$	$**8.77_{[2,8]}$	$*0.04_{[2,8]}$	$*0.40_{[4,8]}$	$*1.14_{[4,8]}$	$*0.43_{[4,8]}$
White sucker	$*2.43_{[2,8]}$	$*4.07_{[2,8]}$	$*4.20_{[2,8]}$	$*1.65_{[4,8]}$	$**3.90_{[4,8]}$	$**8.27_{[4,8]}$

* Not significant at α 0.05
** Significant at α 0.05
N.B. Calculated probability value of 0.0543 rounded to 0.05

Multiple Comparison Test (Student-Newman-Keuls)

Species	May	August	October
Alewife (Overall Mean CUE)	70.11	16.67	0.22
Longnose sucker (Overall Mean CUE)	25.67	4.44	3.44

APPENDIX IX

LIST OF COMON AND SCIENTIFIC
NAMES OF FISH SPECIES CAUGHT
BHWP - 1981

	Common Name	Scientific Name
1.	Alewife	Alosa pseudoharengus
2.	Longnose Sucker	Catostomus catostomus
3.	White Sucker	Catostomus commersoni
4.	Gizzard Shad	Dorosoma cepedianum
5.	Round Whitefish	Prosopium cylindraceum
6.	Walleye	Stizostedion vitreum
7.	Yellow Perch	Perca flavescens
8.	Lake Chub	Couesius plumbeus
9.	Golden Redhorse	Moxostoma erythrurum
10.	Channel Catfish	Ictalurus punctatus
11.	Burbot	Lota lota
12.	Smallmouth Bass	Micropterus dolomieui
13.	Rock Bass	Ambloplites rupestris
14.	Rainbow Trout	Salmo gairdneri
15.	Rainbow Smelt	Osmerus mordax
16.	Splake	Salvelinus namaycush x S. Fontinalis
17.	Spottail Shiner	Notropis hudsonius
18.	Carp	Cyprinus carpio
19.	Coho Salmon	Onchorhynchus kisutch
20.	Freshwater Drum	Aplodinatus grunniens
21.	Chinook Salmon	Onchorhynchus tshawytscha
22.	Brown Trout	Salmo trutta
23.	Emerald Shiner	Notropis atherinoides
24.	Northern Pike	Esox lucius
25.	Trout-Perch	Percopsis omiscomaycus

APPENDIX X

LIST OF BENTHIC INVERTEBRATES COLLECTED AT BHWP - 1981

1. Ablabesmyia spp
2. Ablabesmyia T5
3. Acarina
4. Amnicola limosa
5. Amnicola spp
6. Amnicola walkeri
7. Caenis spp
8. Chaetogaster cristallinus
9. Chaetogaster spp
10. Chironomini
11. Corixidae
12. Cricotopus (cricotopus) cylendraceus group
13. Cricotopus (cricotopus) festivellus group
14. Cricotopus (cricotopus) tremulus group
15. Cricotopus (isocladius) laricomalis group
16. Cricotopus bh
17. Cricotopus Bicinctus
18. Cricotopus spp
19. Dicrotendipes spp
20. Dicrotendipes T3
21. Dicrotendipes T4
22. Dicrotendipes T5
23. Elmidae
24. Empididae
25. Gammarus spp
26. Goniobasis spp
27. Gyraulus spp
28. Helisoma spp
29. Heterotrissocladius changi
30. Heterotrissocladius oliveri
31. Hyalella azteca
32. Hydropsyche spp
33. Hydroptila spp
34. Lumbriculidae
35. Lymnaea catascopium
36. Lymnaea spp
37. Marstonia spp
38. Naididae
39. Nais elinguis
40. Nais pardalis
41. Nais simplex
42. Nais spp
43. Nais variabilis
44. Nanocladius cf Balticus
45. Oecetis spp
46. Orthocladiinae
47. Orthocladius nr Mallochi
48. Orthocladius nr Obumbratus
49. Orthocladius Obumbratus
50. Orthocladius ssp

51. Parachironomus T9
52. Paracladopelma spp
53. Parrakiefferiella spp
54. Paratanytarsus spp
55. Phaenopsectra spp
56. Physa spp
57. Potthastia spp
58. Procladius spp
59. Psectrocladius nr Simulans
60. Psectrocladius spp
61. Psectrocladius nr Articaudus
62. Psectrocladius nr Pseudoviridis
63. Pseudochironomus spp
64. Pseudosmittia spp
65. Rheotanytarsus sp 1
66. Slavina appendiculata
67. Synorthocladius spp
68. Tanytarsini
69. Tanytarsus sp 1
70. Tanytarsus sp 2
71. Tanytarsus spp
72. Thienemanniella T2
73. Thienemannimyia group
74. Tubificidae
75. Vejdovskyiella comata

Major Taxa Represented

Diptera	-	Order
Olegochaeta	-	Class
Ephemeraptera	-	Order
Coleoptera	-	Order
Trichoptera	-	Order
Amphipoda	-	Order
Acarima	-	Order
Megagastropoda	-	Order
Basommatophora	-	Order

APPENDIX XI

TWO-WAY ANALYSIS OF VARIANCE OF TOTAL DENSITIES OF BENTHIC ORGANISMS COLLECTED AT BHWP - 1981

Analysis of Variance

Month	Calculated F Statistic	
	Transect	Depth
May	$*0.75_{[6,24]}$	$*0.73_{[4,24]}$
September	-	-
October	$*0.51_{[6,24]}$	$**4.38_{[4,24]}$

* Not significant at $\alpha 0.05$
** Significant at $\alpha 0.05$

POOR

QUALITY

ORIGINAL